United States
Department of
Agriculture

Forest
Service

Engineering
Staff

Washington, D.C.

Aggregate Base and Surfacing Inspection

Self-Study Course

EM-7115-504-100

Engineering Construction
Certification Program

March 1986

Administrative Distribution

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INTRODUCTION

Aggregate Base and Surfacing Inspection is a self-study training course in the field inspection activities necessary to ensure the proper construction of aggregate base and surface courses. It is intended to train inspectors in the Forest Service Engineering Construction Certification Program in the subject of aggregate base and surfacing, and to prepare technical and professional employees to complete the examination successfully.

The Forest Service Engineering Construction Certification Program provides for the certification of engineering personnel based on training and experience (FSM 7115). This training course was prepared to help you qualify for certification. Upon completion of other certification requirements and the recommendation of your Forest Engineer, you will be eligible to take the written examination covering aggregate base and surfacing. The other certification requirements are given in the Engineering Certification Handbook--FSH 7109.17, which is available to you.

The inspection activities discussed in Aggregate Base and Surfacing Inspection include:

(1) Materials inspection and control.

(2) Interpretation of drawings and other contract documents.

(3) Staking and roadbed inspection.

(4) Inspection and control of aggregate placement.

(5) Inspection of compaction and finishing operations.

(6) Measurement and documentation.

The primary references for this course are the appropriate portions of the Forest Service Manual, Forest Service Handbooks (especially the Engineering Certification Handbook--FSH 7109.17, and Filing System Handbook--FSH 6209.11, Chapter 20), and the Forest Service Forms

Catalog (1300-1). These references are readily available to the people working on this course; if necessary, additional copies of each should be ordered from the Directives stock through the Forest Supervisors' and Regional Offices.

DIRECTIONS FOR COURSE USERS

Training Technique

This course has been designed for self-training.

(1) You can work alone.

(2) You can make as many mistakes as necessary for learning--and correct your own mistakes.

(3) You can finish the training at your own speed.

You will keep this book as a reference, so work neatly.

How To Use This Book

This is not an ordinary book. You cannot read it from page to page as you do other books. This book gives you some information and then asks a series of questions about that information. The questions are organized into short quizzes at the ends of sections within chapters. A quiz is found at the end of each chapter to help you review and quiz yourself on what you learned. At the end of the course a Review Quiz covers all the material you have studied throughout the course.

The questions require you to think carefully and draw conclusions. If you have difficulty in answering the questions, review the troublesome sections before going on.

Answers to the questions are given in chapter 8 at the back of the book. To check your work, refer to the answers numbered to match the question you've completed.

This course is based on the 1985 edition of the Forest Service Specifications for Construction of Roads & Bridges (EM 7720-100 and Federal Acquisition Regulations (FAR's), 1984). If references are not made to specific sections of the FS Standard Specifications, the intent is still to use the 1985 edition.

CHAPTER 1
BASIC INFORMATION

This is a preparatory chapter. We will review road structure terms, discuss the basic steps in constructing aggregate base and surface courses, take a quick look at contract documents, preview your inspection responsibilities, and talk about other things basic to your work as an Inspector. By the end of this chapter, you should:

(1) Know the names and functions of the various parts of the road structure and the basic steps in aggregate base and surfacing construction.

(2) Be able to describe the contents, purposes, and order of precedence of the various contract documents.

(3) Be familiar with your basic inspection responsibilities.

Let's begin with a quick review of road structure terms.

ROAD STRUCTURE TERMS

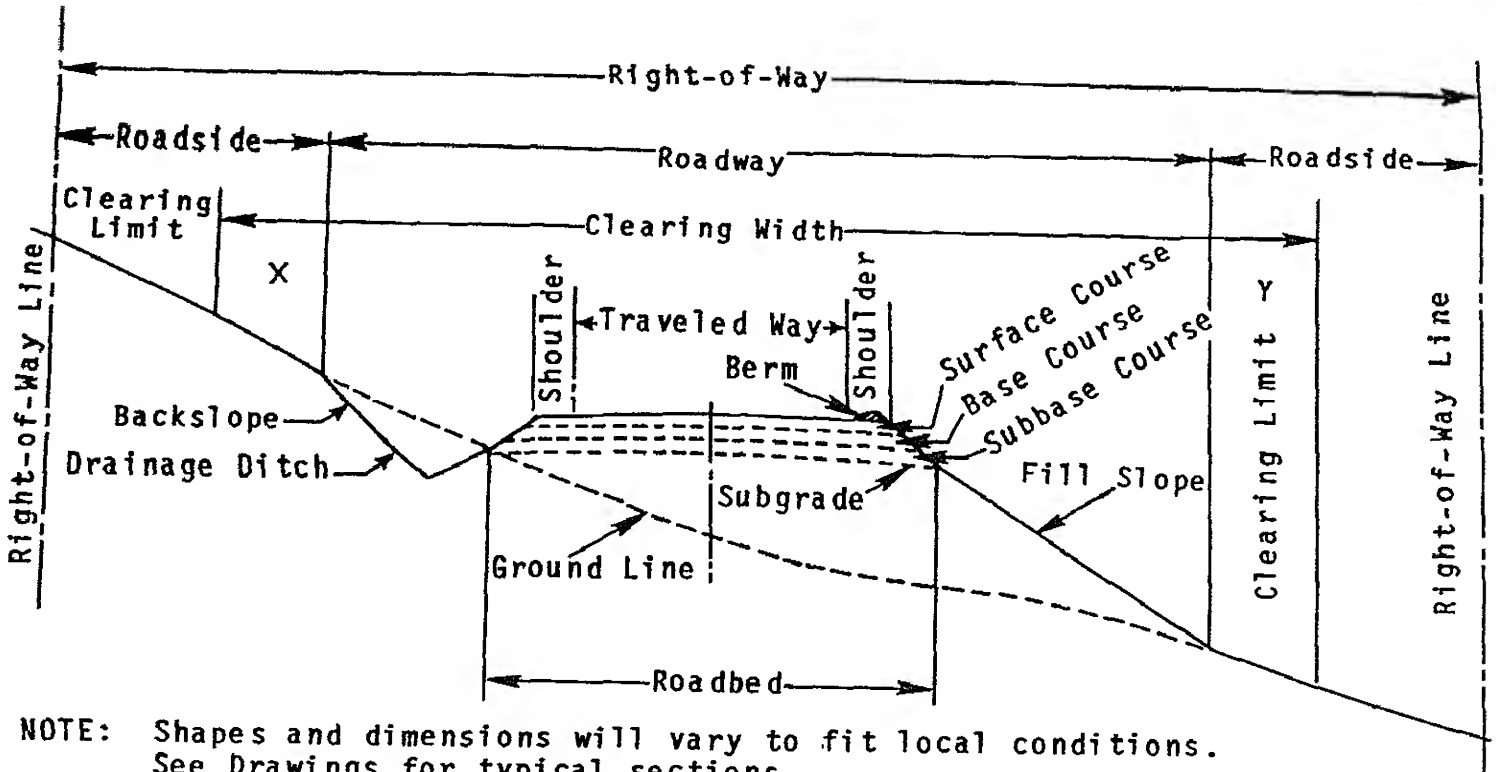
As we discuss aggregate base and surfacing inspection, it's important that you know the standard terms for parts of road structures. It's also important that you know the functions of these different parts. Figure 1-1 illustrates the terms we are concerned with.

Most of the terms in the illustration are self-explanatory, but also remember these few points:

(1) Roadbed consists of suitable native soil. It supports the base and surface courses.

(2) Subgrade consists of suitable native soil, either treated or untreated. It serves as the top of the roadbed. The subbase and/or base course are constructed directly on it.

(3) Subbase consists of either compacted granular material (treated or untreated) or a compacted layer of treated soil. It may help



NOTE: Shapes and dimensions will vary to fit local conditions.
See Drawings for typical sections.
X and Y denote clearing outside of roadway.

Figure 1-1.--Road structure terms.

protect base and surface course from intrusion of fine-grained roadbed soils, damage from frost, and accumulation of free water in or below the pavement structure. (Pavement structure consists of the subbase, base course, and surface course.)

(4) Base Course consists usually of aggregate, either treated or untreated. It serves as the immediate support for the surface course. It may be built directly on subgrade if no subbase is called for. The requirements are more stringent than for subbase.

(5) Surface Course consists of aggregate mixture with binder (either plastic fines or bituminous material). It must carry the traffic load, provide a smooth-riding surface, and resist skidding, traffic wear, and water penetration into the pavement structure.

Study the illustration on page 1-2, then take the quiz.

SEGMENT QUIZ

Refer to figure 1-2 to answer the questions below.

1-1 "C" is the: (Circle or otherwise mark the letter of the correct choice.)

(a) Right-of-way.

(b) Roadbed.

(c) Traveled way.

(d) Cross slope.

1-2 Fill in the blanks:

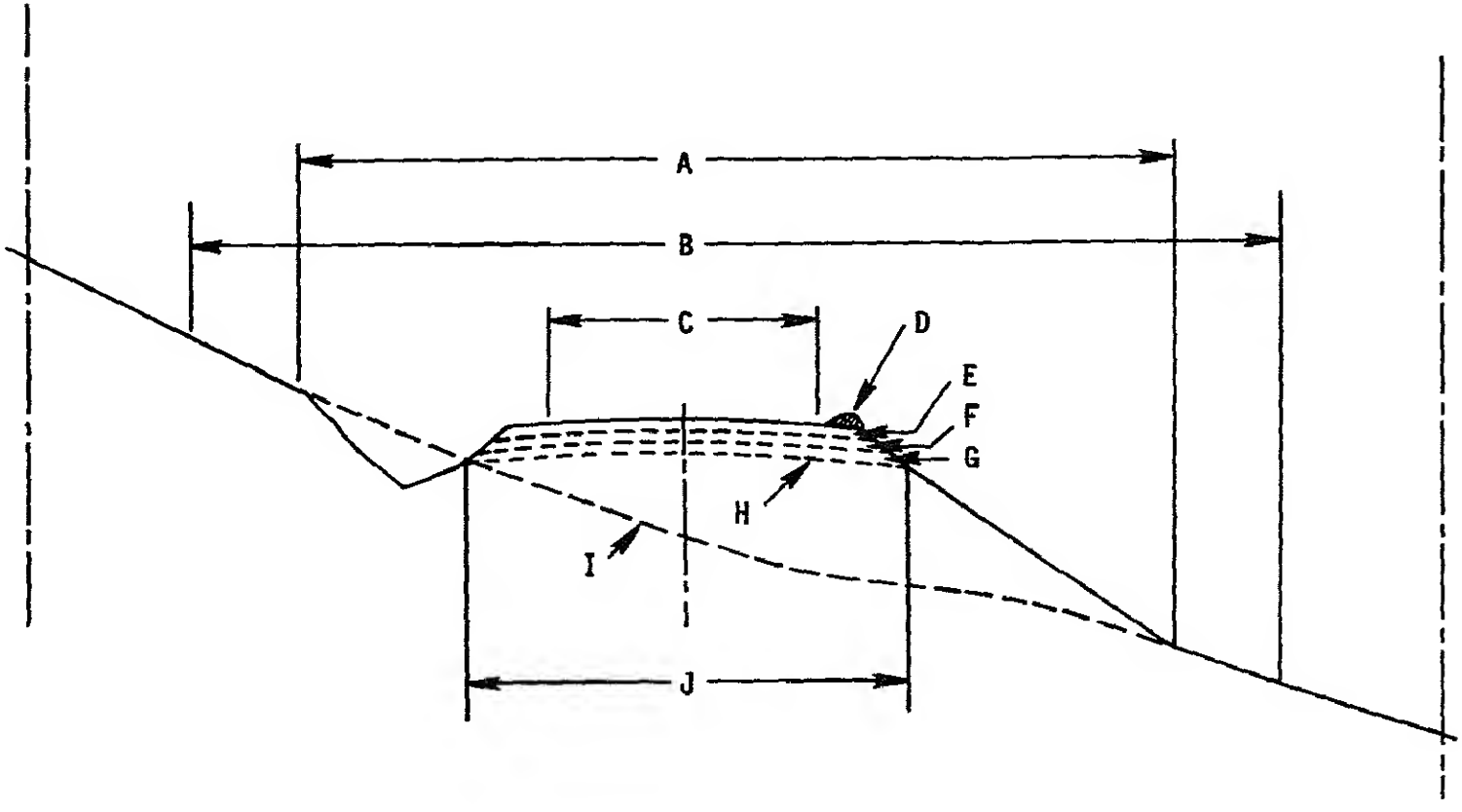
(a) The subgrade is identified by the letter _____.

(b) Letter _____ indicates the subbase.

(c) Which has more stringent requirements, the subbase or the base course? _____ .

(d) Letter "A" indicates the _____.

Do you understand the road structure terms? If you need more review, study figure 1-1 some more. Go on to the next section when you are ready.



igure 1-2.--Road structure terms worksheet.

AGGREGATE BASE & SURFACING CONSTRUCTION

Materials

Aggregate base and surface courses are composed of two basic materials: aggregate and water.

The aggregate--gravel, crushed rock particles, soil, or sand--form the bulk of the base and surface courses. The aggregate is well-graded so that the different particle sizes fit snugly together to form a tight, dense mass.

Water is the other basic ingredient. Some moisture is always present within the aggregate, although more must usually be added during the mixing/placing operations. Water helps hold the aggregate particles together and provides lubrication--making it possible for the particles to be thoroughly compacted.

Other materials are occasionally used in aggregate base and surface courses. These include fillers (or binders), and chemical additives. We will say more about these in chapter 2.

Construction Steps

We can divide the construction of aggregate base and surface courses into several basic steps:

(1) Producing aggregate.

(2) Hauling and dumping aggregate.

(3) Mixing and spreading aggregate (and other materials as necessary).

(4) Compacting and finishing the course.

Producing Aggregate. Aggregate may be produced by crushing, screening, pit-run, or grid-rolling methods. The method to be used will be specified in the contract.

Crushing and screening are the most common methods of producing aggregate. Let's look briefly at these two methods.

Crushers reduce stone and gravel to smaller particles. One type of crusher plant is shown in figure 1-3. You can follow the aggregate flow by referring to the numbers.

(1) The stone or gravel is removed from a pit and fed into the plant's hopper.

(2) The hopper provides a steady supply of material to the conveyor.

(3) The conveyor carries the material to the screens.

(4) The screens separate the particles by size, and oversized material is rejected.

(5) Material already small enough without being crushed is deposited on a conveyor (to step 10).

(6) Material needing to be crushed is carried over the screens.

(7) The coarser material is carried over the top screen and fed into a jaw crusher.

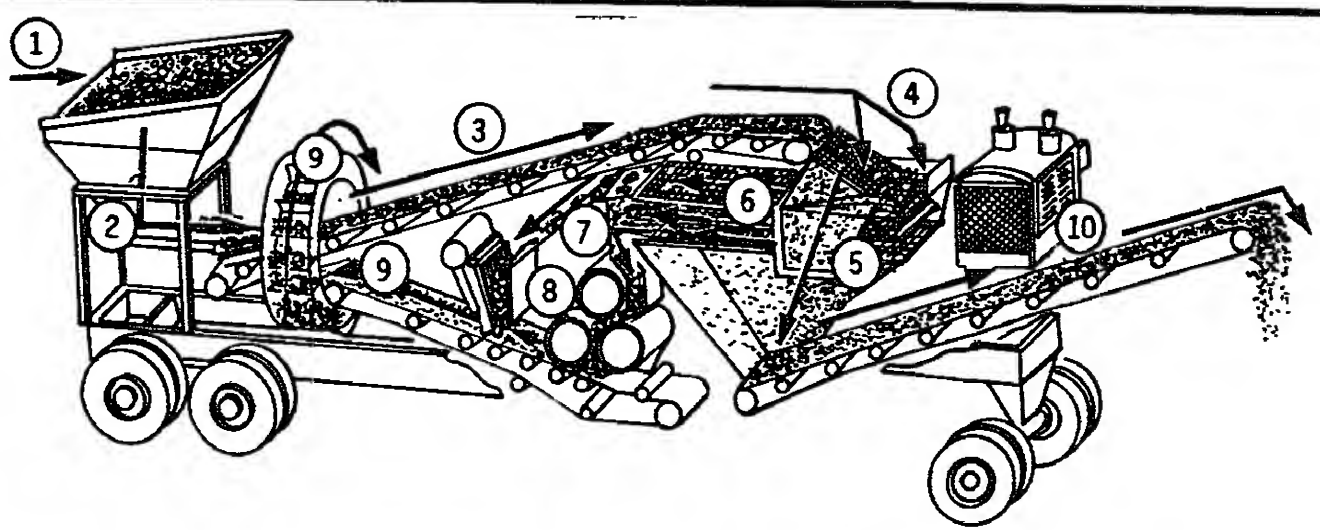


Figure 1-3.--Crushing plant.

(8) The intermediate material is carried to roll crushers.

(9) The material from both crushers is fed onto a conveyor which carries it back to the main conveyor (3). The crushed material passes through the screens again and either goes to the discharge conveyor (10) or back through the crushers to be further reduced in size.

(10) This conveyor carries the material to the waiting haul trucks, to a stockpile, or to a holding bin.

So you see, the purpose of crushing equipment is not only to reduce the size of the aggregate particles, but to blend these sizes back together to obtain the desired mixture or "gradation" of aggregate. The crushed aggregate is then loaded into trucks and hauled to the job site.

Besides the roll crushers and jaw crusher you just saw, there are other types of aggregate crushers. One of these is the cone crusher (figure 1-4).

Cone crushers have a cone-shaped crushing head that gyrates around a vertical axis inside a fixed bowl (figure 1-5). The cone crushes the aggregate several times against the bowl as the material falls between the two.

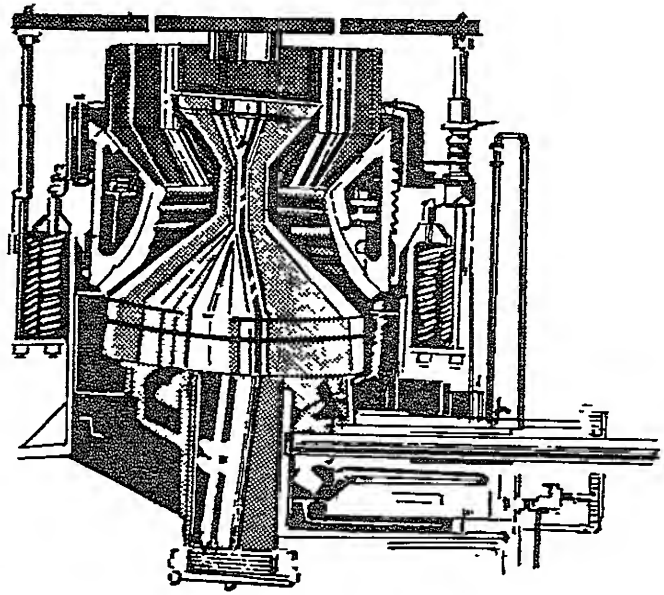
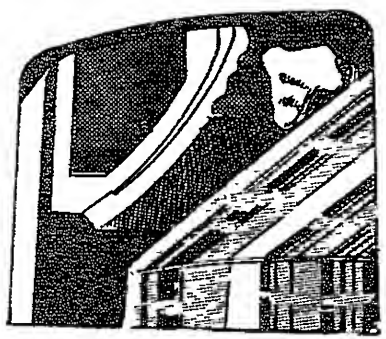
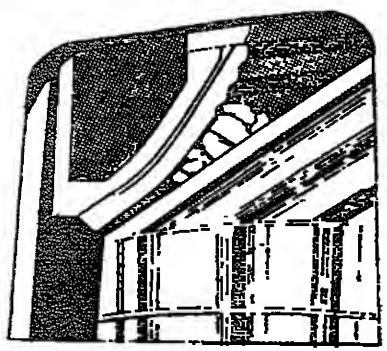


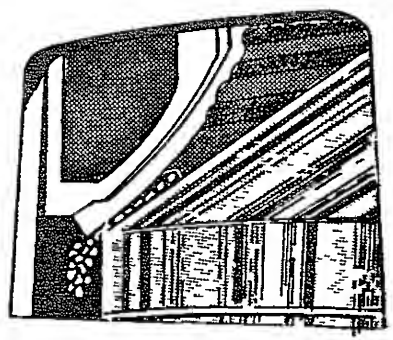
Figure 1-4.--Cone crusher.



Before First Impact



Third Impact



Fifth Impact and Discharge

Figure 1-5.--How the cone crusher works.

Screens of various types and sizes can be used alone to produce aggregate material for base and surfacing. After raw material is removed from the pit it is moved or shaken on the screens, which separate the material into uniform sizes. The relative proportions of the different particle sizes can be adjusted to obtain the desired mixture or "gradation" of aggregate particles. Once screened, the aggregate mixture is hauled to the road for placement. A typical screening apparatus is shown in figure 1-6.

The pit-run and grid-rolling methods generally produce lower quality aggregate.

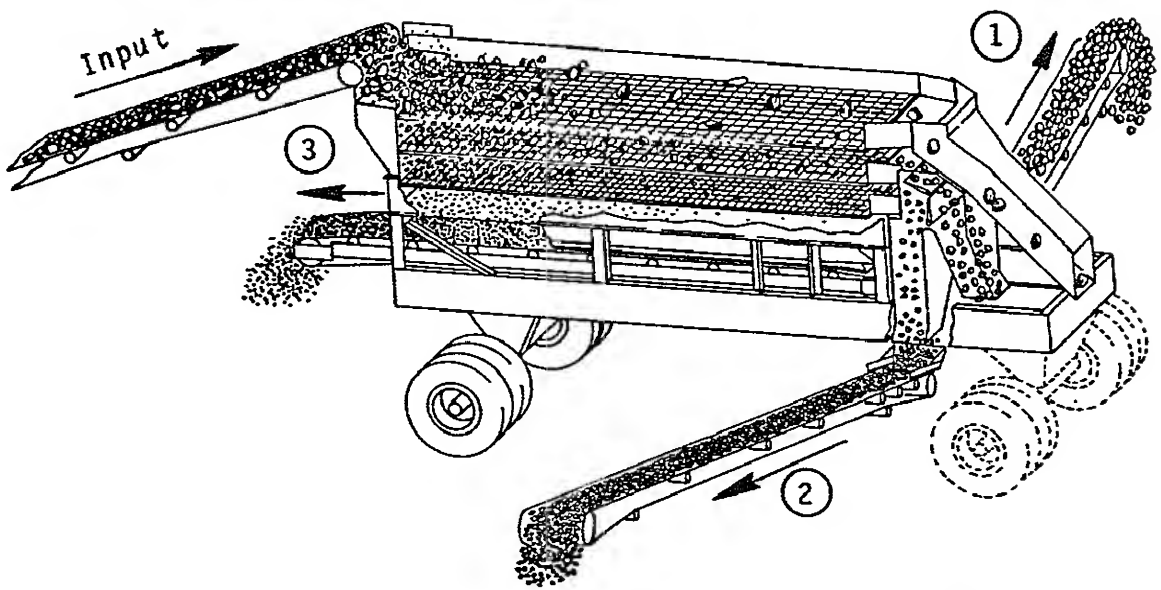


Figure 1-6.--Screening apparatus.

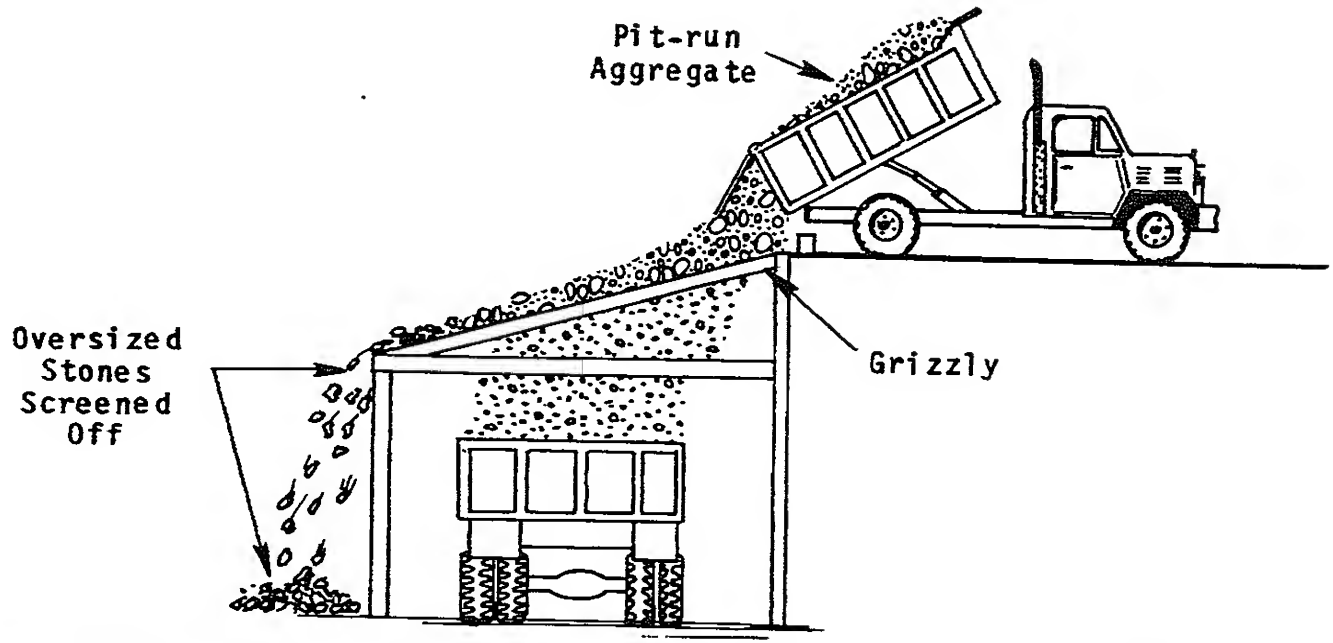


Figure 1-7.--Using a "grizzly."

Pit-run aggregate is simply aggregate that has the proper gradation of particle sizes while in its natural state. That is, no further processing--crushing or screening--is required. Sometimes, however, a "grizzly"--a screen with large openings--is used to sort out any oversized stones (figure 1-7).

Grid-rolling might be described as "crushing in place." Aggregate material may be removed from the pit and placed on the road, or such native materials as shales and weathered talus may be gridrolled. A grizzly is often used to screen off oversized material--larger than, say, 6 inches in diameter. The aggregate is then hauled to the work site and placed on the road.

A heavy steel roller with waffle-pattern surface (figure 1-8) rolls the in-place material, crushing and compacting it at the same time.

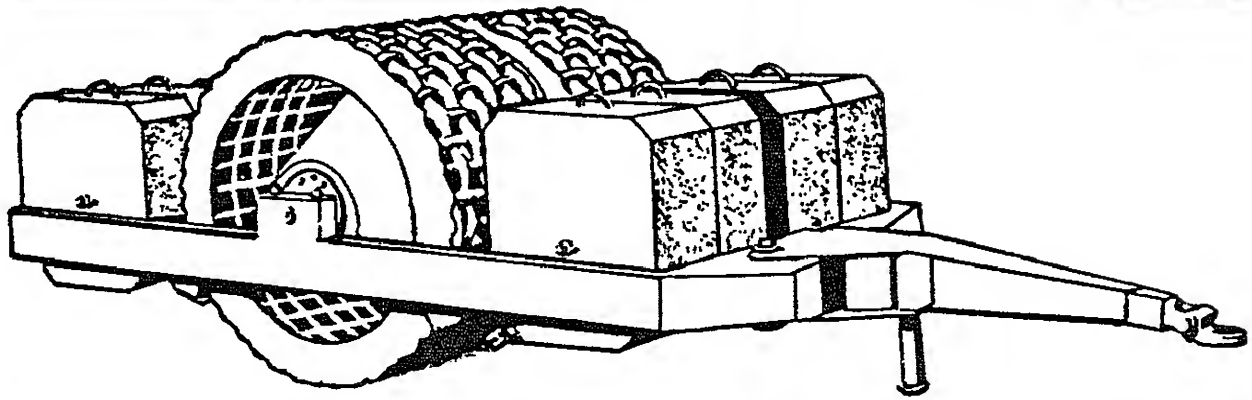


Figure 1-8.--Grid roller.

1-3 Aggregate base and surface courses are composed of two basic materials: _____ and _____.

1-4 Other materials used in aggregate base and surface courses may include:

(a) Asphalt cement.

(b) Fillers.

(c) Chemical additives.

(d) Mulch.

(e) Binders.

1-5 Which of the following would not be included as a basic step in constructing aggregate base or surface courses?

(a) Spreading and mixing aggregate.

(b) Producing aggregate.

(c) Compacting and finishing.

(d) Erecting falsework.

(e) Screeding and curing.

1-6 The purposes of stationary crushers include:

(a) Drying the aggregate.

(b) Reducing the size of aggregate particles.

(c) Blending aggregate sizes to obtain a product with desired gradation.

(d) Compacting aggregate particles in place.

1-7 Well-graded aggregate that can be used directly from the pit is called _____ aggregate.

1-8 The method by which aggregate is crushed and compacted in place is known as _____.

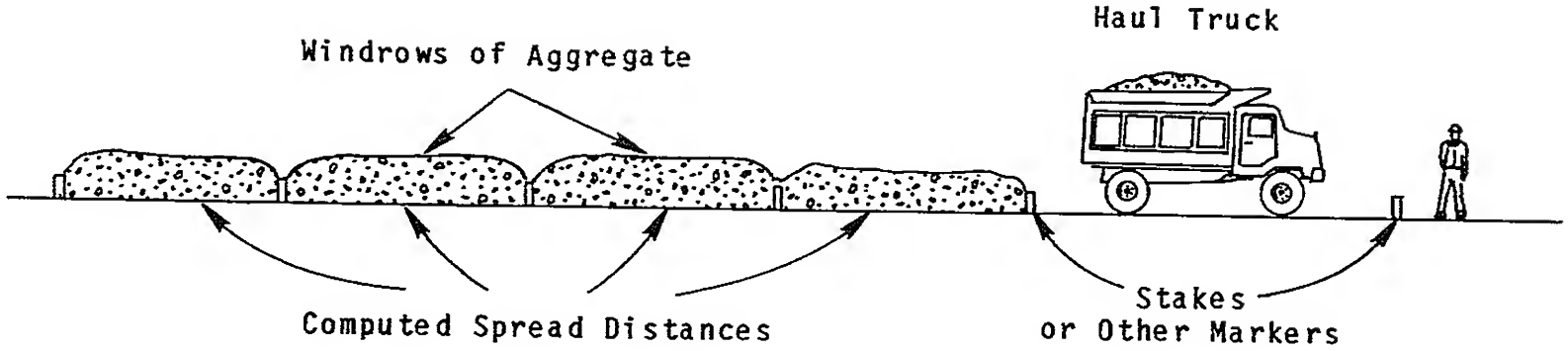


Figure 1-9.--Constructing windrows.

Hauling and Dumping Aggregate. Aggregate produced by crushing, screening, or pit-run operations must be hauled to the job site and dumped on the prepared subgrade or base course.

Grid-rolled material may be either native material or hauled in and placed on the road.

Usually aggregate is dumped on the road and formed by the motorgrader into a "windrow"--a long row paralleling the roadway centerline. This dumping is normally done within computed spread distances that have been staked or otherwise marked on the road (figure 1-9). Sometimes the haul trucks are routed over the already placed aggregate to help compact it.

Mixing and Spreading Aggregate. After the aggregate is dumped in windrows on the road it is mixed and spread. This step involves mixing the aggregate--and adding water as necessary--to achieve a uniform blend with the proper moisture content. Then it involves spreading the aggregate to the required line, width, and depth.

First, a motorgrader evens up the windrow of aggregate, then it cuts material from the windrow by inserting the end of the blade into the windrow's side and carrying the material across the road (figure 1-10).

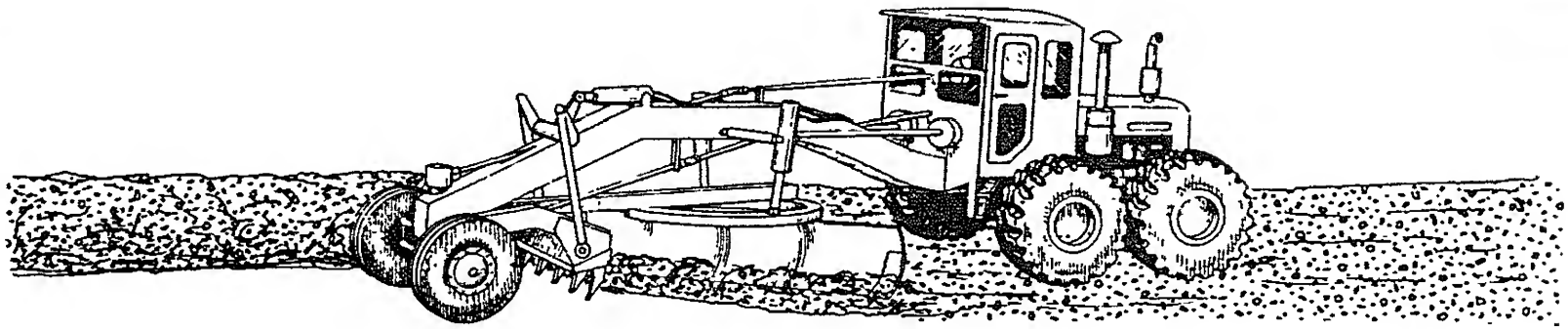


Figure 1-10.--Mixing and spreading aggregate.

Several passes may be needed to cut all the aggregate from the windrow and move it across the road.

It may be necessary to add water to the aggregate at this point. In the case of large windrows, each layer of aggregate should be watered by a water truck as it is spread (figure 1-11). The aggregate from small windrows may be watered just once--after all of it has been cut and spread.

Aggregate mixing and spreading should continue until the material is blended thoroughly and has a uniform moisture content. At this point, final spreading or "laydown" takes place. The aggregate should be spread to the required line, width, and loose depth.

There are other ways besides road-mix to mix and spread aggregate. These include the travel plant and stationary plant methods, which we'll say more about later in the course.

Compacting and Finishing the Course. After the aggregate is properly mixed and spread, it is compacted and finished to obtain the required density and a smooth, even surface.

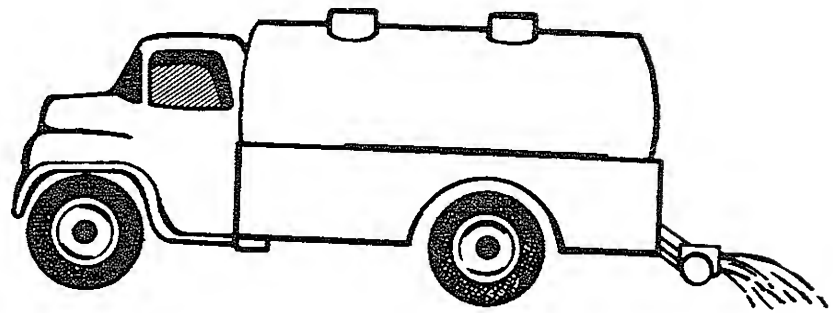


Figure 1-11.--Watering aggregate during spreading.

Various types of rollers may be used to compact and finish aggregate base and surface courses (figure 1-12). Rubber-tired rollers often

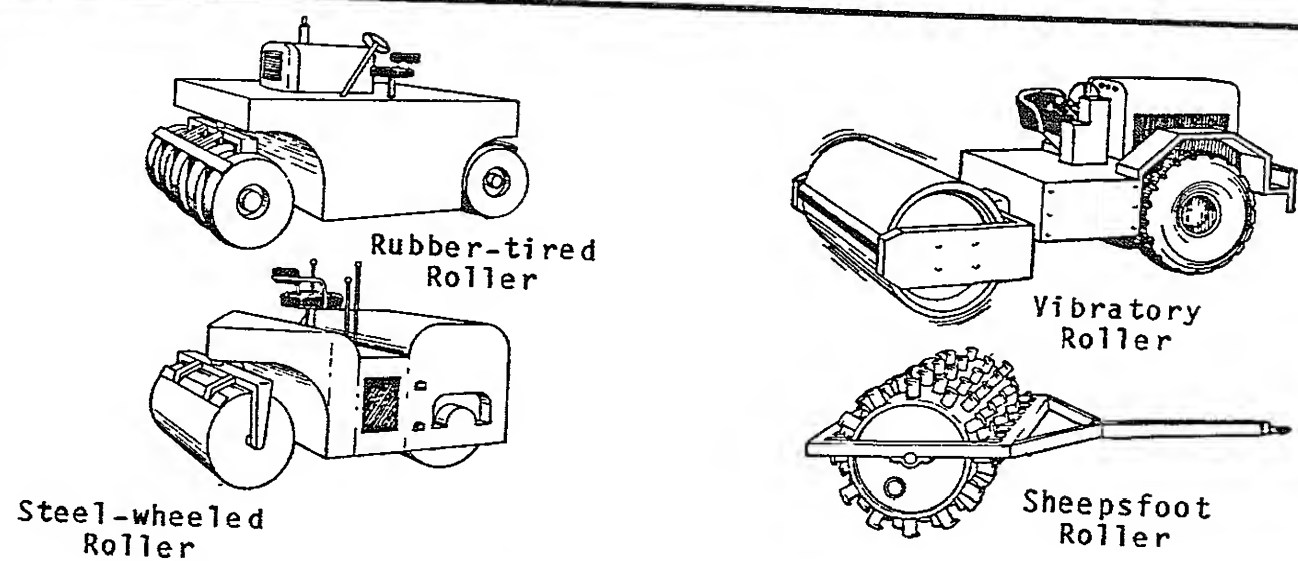


Figure 1-12.--Rollers.

are used for the initial rolling; steel-wheeled rollers are especially effective for the finish (or final) rolling. Vibratory rollers are used in some situations--such as with noncohesive materials in open areas--and sheepsfoot rollers are used in special cases--such as for sand-clay base and surface courses.

We mentioned also that some compaction can be obtained from haul trucks routed over the spread aggregate.

SEGMENT QUIZ

1-9 Usually, aggregate is dumped:

(a) In stockpiles along the shoulder.

(b) In windrows within computed spread distances.

(c) At stationary plants located far from the job site.

1-10 When the aggregate is in large windrows, each layer should be _____ as it is spread.

1-11 What type of roller is especially effective for finish, or final, rolling? _____

CONTRACT DOCUMENTS

Besides being familiar with materials, equipment, and construction steps and methods, you should be well versed in the contract documents that govern construction projects. You should have both:

(1) A general familiarity with the contents and order of precedence of the basic contract documents (see FSH 6309.11, Contract Administration Handbook).

(2) Complete knowledge of the specific documents for the particular project you are assigned.

The contract documents--including the Federal Acquisition Regulations and the Forest Service Specifications for Construction of Roads & Bridges--1985 (EM 7720-100LL), Special Project or Supplemental Specifications, and the drawings--are the official requirements, plans, and directives for carrying out construction projects. The various documents are intended to be complementary--they should agree with and clarify each other.

Sometimes, however, contract documents disagree. In case of discrepancy within formal contracts, the following order of precedence (highest to lowest) generally applies:

(1) Solicitation Documents

(2) Inspection, Acceptance, and Measurement and Payment

(3) Contract Administration, Labor Provisions, and Special Contract Requirements

(4) Special Project Specifications

(5) General Specifications

(6) Drawings and Exhibits

Remember, the order of precedence shown on this page is typical. But we should emphasize the need to know the relationships of the contract documents on each project, since the order of precedence may differ.

We should also point out that while specifications are revised periodically, projects already underway will be governed by the specifications in force at the time of letting.

In addition to the documents listed on page 1-22, timber sale contracts also include so-called "B" Clauses and may include "C" Clauses as well. "B" Clauses are standard provisions and "C" Clauses amount to special provisions.

We will be talking more about contract documents--and will show some examples--in later chapters.

First, take the short quiz that follows.

SEGMENT QUIZ

1-12 Which document or item in the following pairs has precedence over the other in cases of discrepancy?

(a) Drawings.
(b) Specifications.

(c) Special Contract Requirements.
(d) Special Project Specifications.

(e) General Specifications.
(f) Solicitation Documents.

1-13 The order of precedence shown on page 1-19 is:

(a) Fixed by law and cannot vary.

(b) Common only to timber sale contracts.

(c) Typical, but may change from contract to contract.

1-14 Timber contracts include standard provisions known as ____ Clauses and special provisions referred to as ____ Clauses.

INSPECTOR'S RESPONSIBILITIES

As an Inspector of aggregate base and surface course construction, you have important responsibilities. We can divide them into three categories for our discussion: contract administration authority, job performance requirements, and letter of designation.

Contract Administration Authority

For all contracts to which you may be assigned, you have the general authority and responsibility to inspect the materials, the workmanship, and the work itself for compliance with plans and specifications. You will always work under the direct supervision of the Contracting Officer's Representative (COR) on public works projects, or the Engineering Representative (ER) on timber sale jobs. In this course, we will use the general title "Engineer" to include both. When we want to refer to just one, we will use the specific title.

Your primary functions are to:

(1) Check the Contractor's operations for compliance with the contract's technical specifications, drawings, work schedules, and labor standards.

(2) Advise the Contractor promptly in writing about any deviations from the items in number 1 above.

(3) Report promptly to the Engineer any Contractor refusal or failure to comply with the contract requirements.

(4) Keep progress reports on and an official daily dairy of all actions, happenings, and other developments that may be useful in the event of a later dispute or investigation.

The Engineer (and/or Contracting Officer) has the specific responsibility of ensuring the Contractor's compliance with contract terms and conditions. That person--not you--has the authority to make changes and issue Stop and Resume Work Orders.

As an Inspector, you are <u>not</u> to act as foreman, perform any duties for the Contractor, or interfere with the Contractor's management of the work.

Job Performance Requirements

Job Performance Requirements (JPR's) are detailed lists of standard inspection duties for specific items of work (FSH 7109-17). The JPR for aggregate base and surfacing begins below and continues through page___. Study it now.

21.31b--Aggregate Base and Surfacing

1. JPR 1. Ensure quality control during the life of the contract.

   Critical incidents:

   a. Determines from the contract the requirements for the physical properties of the aggregate, and the tests required to be performed on the aggregate.

   b. Determines from the contract and approved references the required frequency of sampling and testing materials, locations from which representative samples will be obtained, and required size of samples. Determines sampling procedures to be used.

   c. Selects proper equipment and tools needed for sampling and obtains representative samples of aggregate using standard, accepted, and approved procedures and techniques.

   d. Performs required tests on the samples of aggregate: Sampling and Testing.

   e. Compares test results with contract requirements and states specifically how the aggregate meets or fails to meet contract requirements.

   f. Ensures that the aggregate meets contract requirements.

2. JPR 2. Ensure that the subgrade is prepared in accordance with the contract.

   Critical incidents:

   a. Determines from the contract the requirements for preparing the roadway prior to placing aggregate. Performs all required

tests and describes requirements so that the Contractor or designated representative knows what is expected.

b. Compares the roadway as actually prepared with contract requirements; determines if the roadway meets requirements and if the roadway is ready for the placement of aggregate. States how the roadway does or does not meet those requirements.

c. Ensures that roadway preparation deficiencies are corrected.

3. JPR 3. Ensure that the aggregate material is stockpiled, placed, and compacted in accordance with the contract.

Critical incidents:

a. Determines from the contract and accepted standards the requirements, methods, and sequence of hauling, dumping, spreading, processing, compacting, and stockpiling the aggregates.

b. Identifies from the contract where and to what dimensions aggregates are to be placed on the roadway.

c. Determines from the contract and Contractor's proposed plan of operations what stakes, marks, or other ground controls are needed to control the placement of aggregate to the required dimensions.

d. Determines and describes procedures for dumping trucks or spreading trucks so that the required amount of aggregate can be placed to the required dimensions.

e. Determines whether compaction requirements are being or have been met.

f. Determines whether contract requirements relating to stockpiling, hauling, processing, and spreading are being met.

g. Ensures that the aggregate has been hauled, dumped, processed, spread, compacted, or stockpiled in accordance with contract requirements.

Letter of Designation

While your contract administration authority is a set of general responsibilities for all contracts you work on, and the JPR's list your standard duties on all aggregate base and surfacing projects, you will also receive specific instructions for each contract.

These specific directions come in the form of a "Designation of Inspector" letter that designates you as the Inspector for that particular job. A sample "Designation of Inspector" letter appears in figure 1-13. Look it over, then go on to the quiz.

USDA-FOREST SERVICE R1-6320-29 (8/74)

DESIGNATION OF INSPECTOR
(Reference FSH 6309.11 Ch. 10)

To:
ED BYRNES
ENGINEERING SECTION
BOULDERDASH NATIONAL FOREST
ANYTOWN, USA 12345

Date: APRIL 3, 1978
Contract Number: 26-4012
Contractor: NATIONAL CONSTRUCTION CO.
Project: BIG PINE ROAD

You are designated as inspector on this project with responsibility for:

1. Checking contractor's performance for compliance with the technical specifications, drawings, work schedules, and Labor Standards provisions of the contract.

2. Notifying the contractor by work order when work is not being done, or materials being furnished are not in compliance with the contract.

3. Reporting to me any refusal or failure by the contractor to comply with the contract provisions.

4. Maintaining a project diary of all occurrences or developments which occur while you are on the project.

All direct actions taken to secure contractor's compliance with any portion of the contract, including issuance of work orders for other than rejections under item 2 above, or suspend and resume work orders, and any changes, are my specific responsibility.

Please refer to me any questions regarding interpretation of specifications.

Remarks

YOUR DUTIES AS INSPECTOR ARE LIMITED TO WORK BEING PERFORMED UNDER ITEM NO. 304 -- AGGREGATE BASE OR SURFACE COURSE.

Distribution:
Original - Inspector
Pink cc - Contracting Officer
Blue cc - Contractor
Yellow cc - COR

Signature
Robert W. Johnson
Contracting Officer's Representative

Figure 1-13.--Sample "Designation of Inspector" letter.

SEGMENT QUIZ

1-15 As an Inspector, you will work under the direct supervision of the:

(a) Contractor.

(b) District Ranger.

(c) Project Manager.

(d) COR or ER.

1-16 Which of the following are <u>not</u> among your inspection duties and responsibilities?

(a) Help Contractor manage work.

(b) Keep progress reports.

(c) Advise Contractor in writing about deviations from contract requirements.

(d) Issue Stop and Resume Work Orders.

(e) Check Contractor's operations for compliance with technical specifications, drawings, work schedules, and so forth.

(f) Serve as foreman when necessary.

1-17 Which of the following are your responsibilities as an Inspector of aggregate base and surfacing?

(a) Identify from the contract where and to what dimensions aggregate is to be placed on the roadway.

(b) Select the source for the aggregate and determine the method by which it should be furnished.

(c) Determine whether compaction requirements are being or have been met.

(d) Ensure that roadway preparation deficiencies are corrected.

1-18 OFA stands for _____.

1-19 True or false? You will have to compare test results with contract requirements and state specifically how the aggregate meets or fails to meet those requirements. _____

CHAPTER QUIZ

Until now the quizzes have covered the sections they immediately follow. This quiz, however, reviews the whole chapter, asking questions on all the basic points we've covered. You'll find a similar quiz at the end of each chapter.

1-20 What part of the pavement structure serves as the immediate support for the surface course? _____

1-21 When aggregate is dumped from haul trucks at the road, it is usually placed:

(a) In windrows within computed spread distances.

(b) In stockpiles located at existing turnouts.

(c) In stationary mixers.

(d) By "grizzlies."

1-22 "B" and "C" Clauses are standard provisions of _____ contracts.

1-23 Suppose you find a disagreement between the Specifications and the drawings. Which should you go by? _____.

1-24 Are you responsible for checking the Contractor's operations for compliance with the labor standards of the contract? _____

1-25 Which of the following is accomplished by a "Designation of Inspector" letter?

(a) Gives you the authority to issue Stop Work Orders.

(b) Gives the Contractor a "Notice to Place."

(c) Designates you as the Inspector for a particular contract.

(d) Gives you specific instructions for a job.

CHAPTER 2
CONTROLLING the MATERIALS

The materials used in constructing aggregate base and surface courses must meet certain requirements as specified in the contract documents.

In chapter 1 you learned that aggregate base and surfacing materials include:

(1) Aggregate.

(2) Water.

(3) Filler or binder.

(4) Chemical additives.

In this chapter, we'll look at the requirements for each of these materials. By the end of the chapter you should:

(1) Be able to determine from contract documents the requirements for source, gradation, and quality of aggregate.

(2) Be able to determine from contract documents the material requirements for chemical additives, water, fillers, and binders.

(3) Know which tests and inspections to perform on the materials, why and when they are performed, and how the test results are used to administer and control the work.

(4) Know the actions to take in cases of failed tests or inspections.

AGGREGATE

By "aggregate" we mean combinations of crushed stone, gravel, crushed gravel, sand, slag, or other mineral materials.

Types of Aggregate

Crushed Stone. Crushed stone is the product that results from crushing bedrock. Nearly all the faces of the fragments are fractured.

Gravel. Gravel is naturally occurring coarse granular material, usually defined (according to the Unified Soil Classification System), as material that is retained on a No. 4 screen and that passes a 3-inch screen. It results from the natural weathering and erosion of rock.

Crushed Gravel. Crushed gravel is produced by crushing ordinary gravel. The number of fractured faces resulting from crushing will depend on the original gradation of the natural gravel. The coarser the gradation, the higher the percentage of fractured faces.

Sand. Sand is fine granular material defined (according to the Unified Soil Classification System) as material passing a No. 4 sieve but retained on a No. 200 sieve. It results from the natural disintegration of rock.

Slag. Slag is a byproduct of steel production in blast furnaces and, as a result, is found primarily in industrial regions of the country.

Contract Requirements

The contract requirements for aggregate can be divided into three categories:

(1) Source.

(2) Gradation.

(3) Quality.

Let's look at each category.

Source. Aggregate can come from Government (Forest Service)-designated or Contractor-furnished sources.

Sources indicated by the Forest Service are either designated or described on the drawings or in the Special Project Specifications. The Government assumes responsibility for the quality and quantity of

material in the source. The Contractor must determine the equipment and work methods to produce aggregate that meets requirements. This includes selection or rejection of material within the source area to meet product specifications.

In locating acceptable aggregate sources, the Forest Service investigates sites and takes samples of material. Although the samples give a good indication of the nature and extent of the aggregate, the exact limits of the deposit cannot be determined and variations are to be expected.

The Contractor should use the material in the source to the fullest possible extent. For crushing operations, this normally means using all suitable material with a diameter of 12 inches or less. Grid-rolling operations should use all suitable material that can be reduced to the maximum size shown in the Schedule of Items. These requirements may change, however--always check the contract documents.

The designation of the source includes the Contractor's rights to use certain area(s) for crushing and screening equipment, stockpiles, and haul roads. The Special Project Specifications set forth any requirements for Contractor royalty payment.

If--due to causes beyond the Contractor's control--a designated source contains insufficient acceptable material, the Government will provide another source with an equitable pay adjustment.

We should say a little about Contractor-furnished sources. A Contractor may furnish the aggregate source for one of two reasons: the Forest Service has not designated the source or the Contractor has chosen not to use the designated source. In either case, the Contractor is responsible for providing the specified product, usually with no adjustment in contract price.

For Contractor-furnished sources, the preliminary aggregate quality testing becomes the Contractor's responsibility. He must furnish test results, for instance, AASHTO T 96 and T 210, to the Engineer to prove acceptability.

SEGMENT QUIZ

2-1 The term "aggregate" may mean:

(a) Sand.

(b) Crushed gravel.

(c) Cement.

(d) Vegetable matter.

(e) Crushed stone.

2-2 Gravel is usually defined as being:

(a) Fractured on all faces.

(b) Lighter than 1.5 ounces per particle.

(c) Retained on a No. 4 sieve.

(d) Smaller than $\frac{3}{4}$ inch in circumference.

2-3 Aggregate sources designated by the Forest Service are either designated or described on the _____ or in the _____.

2-4 For Government-designated sources, who assumes responsibility for the quality and quantity of material? _____

2-5 For Government-designated sources, who must determine the equipment and work method to produce aggregate that meets requirements? _____

2-6 For crushing operations, the Contractor should use all suitable material with a diameter of _____ or less.

2-7 For grid-rolling, pit-run, and screening operations, the Contractor should use all suitable material that can be reduced to:

(a) Minus-200 material.

(b) A maximum size as shown in the Schedule of Items.

(c) A minimum of plus-8 material.

(d) A maximum specific gravity of 2.67.

2-8 Can the exact limits of an aggregate source be determined from samples taken from test holes? _____

2-9 True or false? The designation of the aggregate source by the Government includes the rights of the Contractor to use certain area(s) for crushing and screening equipment, stockpiles, and haul roads. _____

2-10 For Contractor-furnished sources, who is responsible for preliminary quality testing to prove aggregate acceptability?

"Pit plans" are usually required for aggregate sources. Part of a sample pit plan for a Government-designated source is shown in figure 2-1. It has been greatly reduced in size from a set of project drawings. Study the example.

In looking over the sample pit plan, you probably noticed that:

(1) Contour, or elevation, lines are shown.

(2) The approximate pit boundary is indicated.

(3) The locations of test holes are marked.

(4) An existing primitive road is shown.

(5) Instructions for working and restoring the pit are included.

As an Inspector, you should note especially the last item above. Be sure that the Contractor works the pit and restores it according to the requirements.

You should also be aware that the Contractor is required to observe good safety practices. This includes strict adherence to Occupational Safety and Health Administration (OSHA) and Mining Enforcement Safety Administration (MESA) requirements for quarry operations. You should inform the Contractor of unsafe practices; however, you do not have enforcement authority unless there is an immediate threat of injury or death.

Besides the source requirements given in the FS Standard Specifications and in the pit plan, additional requirements may be included in other documents, such as the Special Project Specifications shown in figure 2-2.

As an Inspector, you have the responsibility to learn <u>all</u> aggregate source requirements for each job--and to see that the Contractor observes them.

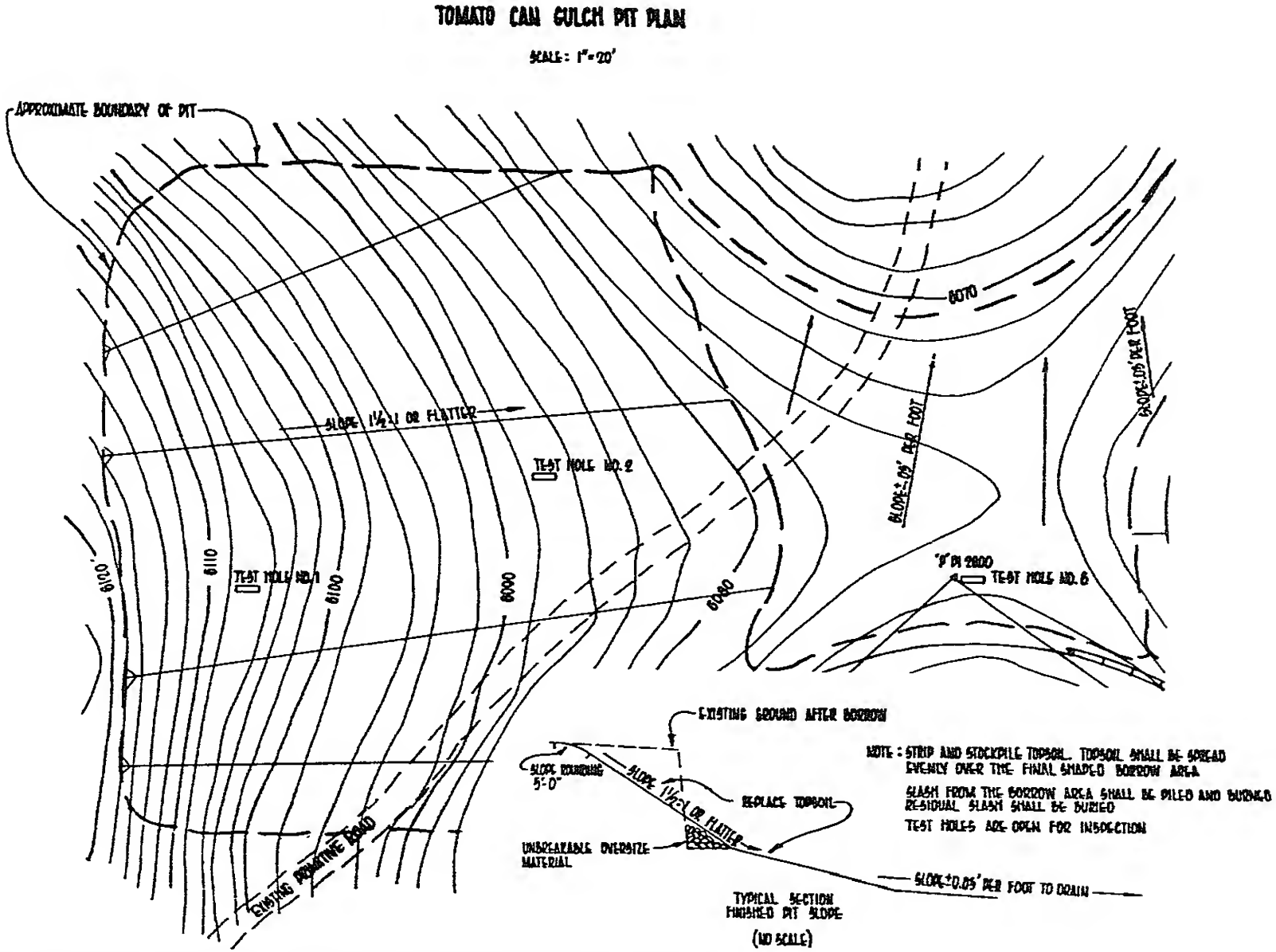


Figure 2-1.--Sample pit plan (Government-designated aggregate source).

R1-11-77-94
SPECIAL PROJECT SPECIFICATIONS

SECTION 304 - AGGREGATE BASE OR SURFACE COURSE

304.02 Source. Add the following:

All clearing and slash cleanup in the pit area shall be completed and accepted before the crushing operation begins. After excavation the sides of the pit shall be sloped and the bottom free draining as shown on the plans. The general pit area shall be smoothed. Any reject material shall be stockpiled in the pit and become the property of the Government.

Figure 2-2.--Source requirements in Special Project Specifications.

SEGMENT QUIZ

2-11 Which of the following would you expect to find on a pit plan?

(a) Locations of the test holes.

(b) Instructions for sloping the sides of the pit.

(c) Approximate pit boundaries.

(d) Contour (elevation) lines.

2-12 The Contractor should observe the quarry safety requirements of:

(a) ASTM.

(b) MESA.

(c) AASHTO.

(d) OSHA.

2-13 According to the Tomato Can Gulch pit plan (figure 2-1), what slopes should the sides of the pit have? _____

Gradation. Aggregate gradation is one measure of suitability for use in base and surfacing construction.

What do we mean by "gradation"? Well, we are really talking about the sizes of aggregate particles and the relative distribution of these particle sizes in the aggregate material.

The relative distribution of the particles is expressed as the percentage (by weight) of particle sizes in the total material. For example, let's say that 19 percent of the total material is aggregate in the range of 1" to 1½"; 34 percent consists of ½" to No. 4 aggregate, and so on, as shown in figure 2-3.

Gradation is determined by sieving. A sample of the aggregate material being tested is dried, weighed, and then passed through a series of sieves (figure 2-4). The contents of each sieve are then weighed. Sieve sizes correspond to the size of the openings in the mesh (figure 2-5). Figure 2-6 shows a range of mesh openings and the corresponding aggregate sizes.

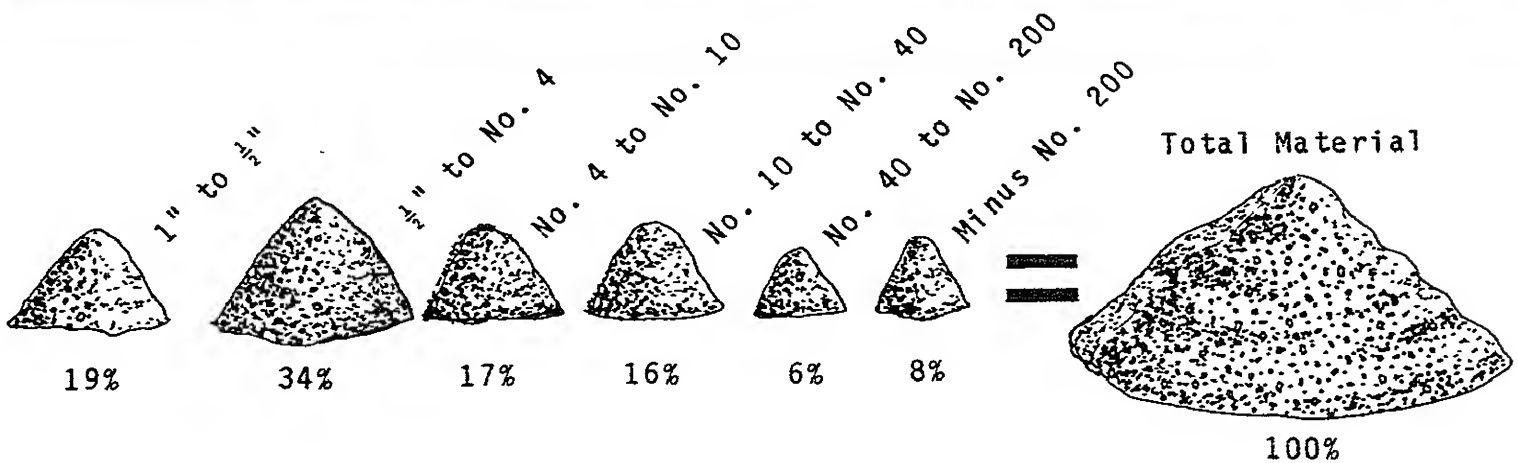


Figure 2-3.--Relative distribution.

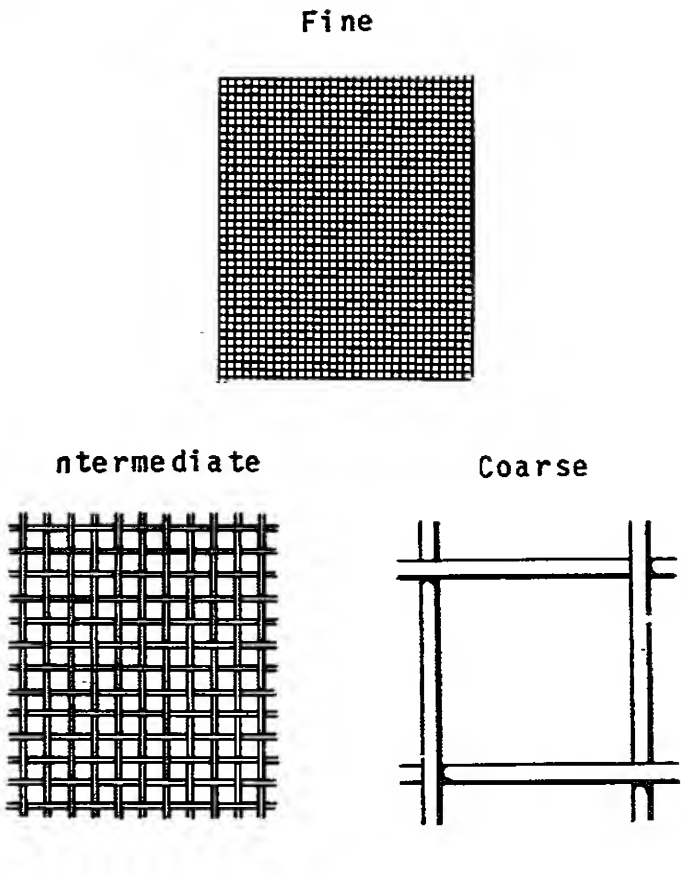


Figure 2-4.--Sieving to determine gradation.

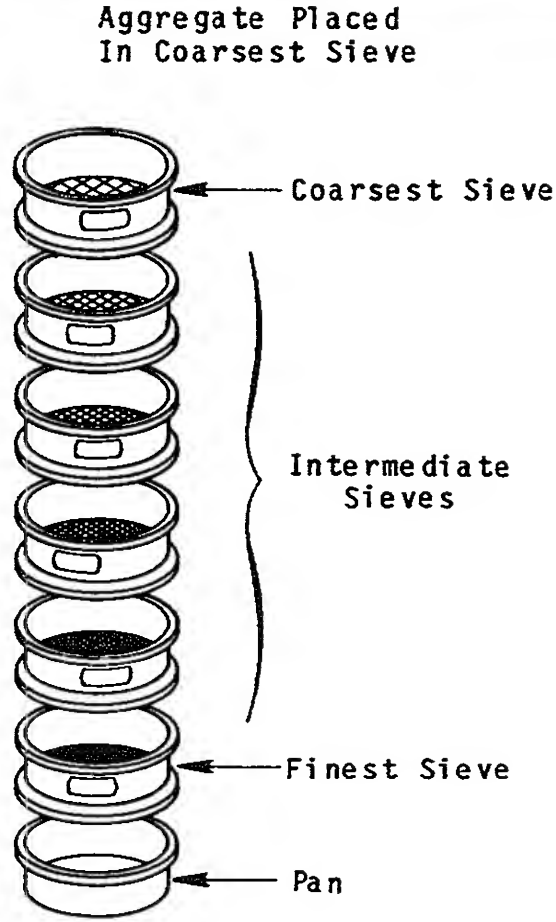


Figure 2-5.--Sieve sizes.

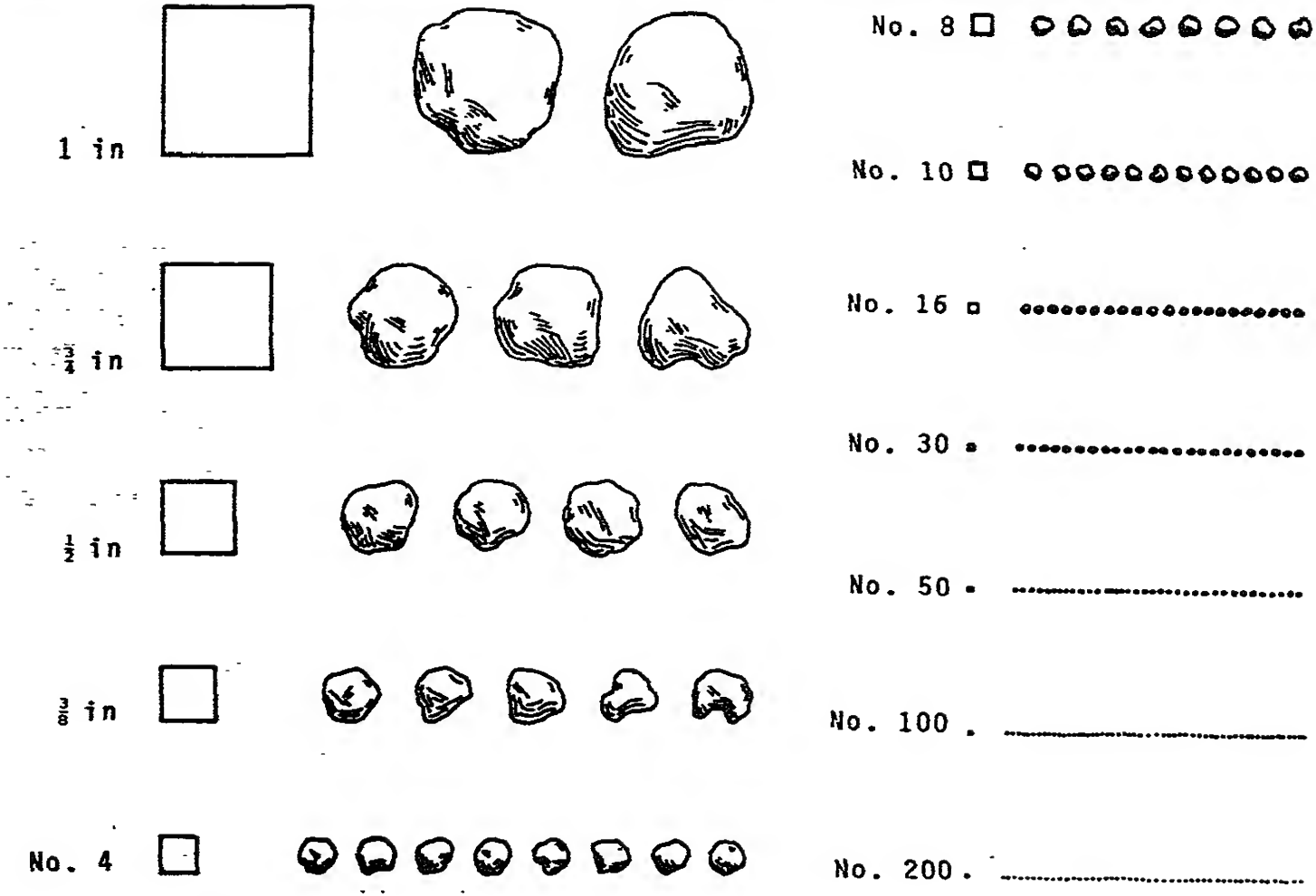


Figure 2-6.--Sieve and corresponding aggregate sizes.

Coarser sieves are classified according to the size of the openings, in linear inches. Thus, the 1-inch sieve has openings of 1 square inch.

In describing aggregate size, plus means coarser than and minus means finer than. For instance, particles coarser than the $\frac{3}{4}$-inch sieve are called plus $\frac{3}{4}$-inch material; aggregate finer than the $\frac{3}{4}$-inch sieve is called minus $\frac{3}{4}$-inch material. To be retained on any sieve, the particles must be coarser than the sieve size in every direction, as they are shaken thoroughly over the screen.

The smallest sieve measured in inches is a $\frac{1}{4}$-inch sieve. The No. 4 sieve, and those with finer openings, are classified according to the number of openings per linear inch. A No. 4 sieve is slightly finer than a $\frac{1}{4}$-inch sieve. A 1-square-inch section of a No. 4 sieve is reproduced in figure 2-7.

A No. 10 sieve has 10 openings per linear inch (figure 2-7).

The No. 100 sieve is four times as fine as the No. 50. The No. 200 sieve is so fine that it looks like silk. Dust from the aggregate particles is the only material that will pass the No. 200 sieve.

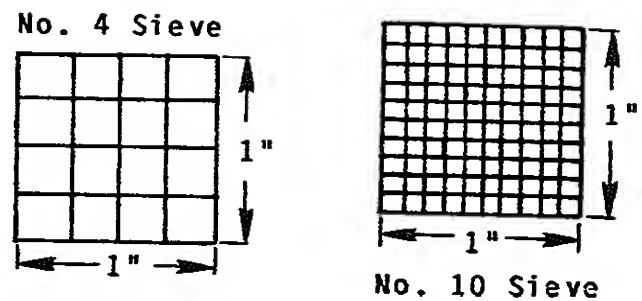


Figure 2-7.--Square-inch sections of linear inch sieves.

SEGMENT QUIZ

2-14 Gradation is the _____ _____--by weight--of aggregate particle sizes within the total aggregate material.

2-15 Sieve sizes correspond to the size of the:

(a) Openings in the mesh.

(b) Sieve frame diameters.

(c) Aggregate samples.

(d) Relative distribution.

2-16 A sieve with 30 openings per linear inch is classified as a:

(a) 0.033-inch sieve.

(b) $\frac{1}{30}$-inch sieve.

(c) Coarse sieve.

(d) No. 30 sieve.

2-17 How many openings are there in 1 square inch of a No. 16 sieve?

The results of sieving can be expressed or tabulated as the cumulative percentage of aggregates passing a given size, or the percentage between sieves. Table 2-1 shows how one gradation can be expressed in both ways.

Do you understand how the percentage passing and percentage between are related, and how they are different ways of tabulating the same test results?

How do you know how to tabulate the sieving results? Well, this depends on how the gradation requirements are expressed. For example, if the requirements are based on percentage passing--which is usually the case--then the test results should be tabulated as percentage passing. Note that the gradation shown in the table is the same as that illustrated in figure 2-3.

Table 2.1--Sieve analysis for a graded aggregate.

Sieve Size	Opening		Percentage Between	Percentage Passing
	in	mm		
1 in.	1.00	25.0	19	100
½ in.	0.500	12.5	34	81
No. 4	0.187	4.75	17	47
No. 10	0.787	2.00	16	30
No. 40	0.0165	0.425	6	14
No. 200	0.0029	0.075	8	8
Pan	0.0	0.0	0	0

Aggregate gradation requirements depend on how the aggregate is produced. For aggregate produced by crushing or screening, the requirements are shown on drawings in the Supplemental Specifications or in the Special Project Specifications.

There are no standard gradation requirements--other than maximum size--for pit-run or grid-rolled material. However, always check the Special Project Specifications. Any oversized material remaining after the aggregate is processed on the road must be removed and disposed of as shown on the drawing or in the Supplemental Specifications.

A Special Project Specification covering gradation requirements is shown in figure 2-8. This project involves the furnishing of

	Percentages by Weight Passing Square Mesh Sieves (AASHTO T 27 and T 11)							
Sieve Designation	BC-1	BC-2	BC-3	BC-4	BC-5	BC-6	BC-7	BC-8
4 inch	100							
3 inch	-	100						
2 inch	-	-	100	100				
1½ inch	-	-	-	-	100	100		
1 inch	-	-	59-87	-	70-98	-	100	100
¾ inch	-	-	-	-	-	-	-	
½ inch	-	-	40-68	-	48-76	-	50-70	60-88
No. 4	-	-	22-46	-	28-52	-	20-40	35-59
No. 10	-	-	14-34	-	17-37	-	10-20	22-42
No. 40	-	-	5-19	-	7-21	-	0-10	9-23
No. 200	-	-	0-10	-	0-10	-	0-6	3-9

Figure 2-8.--Gradation requirements shown in a Special Project Specification.

aggregate by crushing. Look over the example now.

The gradations should conform to the sizes shown in figure 2-8. Note that a percentage range is given for each sieve designation (except for the 100 percent requirements). This means that any percentage passing that falls within the given range will be acceptable. For example, let's say that the sample gradation on pages 2-10 and 2-15 is for size BC-8 material. The percentage passing the No. 4 sieve--47 percent--falls exactly in the middle of the permissible 35-59 percent range.

Now let's summarize our discussion of gradation.

(1) Gradation is the relative distribution--by weight--of aggregate particle sizes within the total aggregate material.

(2) Gradation is determined by sieving. An aggregate sample is first dried, then weighed, then shaken through a series of sieves having progressively smaller mesh openings. Finally, the contents of each sieve are weighed.

(3) Coarser--down to the $\frac{1}{4}$-inch--sieves are classified according to the size of the mesh openings, in linear inches. Finer sieves--from the No. 4 on down--are classified according to the number of openings per linear inch.

(4) The results of sieving are usually shown as the cumulative percentage of aggregate passing each given sieve.

(5) Crushed and screened aggregate gradation requirements are shown on the drawings or in the Specifications. By the current Standard Specifications, there are no gradation requirements for pit-run or grid-rolled aggregate--except for maximum size.

SEGMENT QUIZ

2-18 For aggregate produced by crushing or screening operations, the gradation requirements may be shown in the:

(a) Federal Acquisition Regulations.

(b) General Requirements.

(c) Drawings.

(d) Special Project Specifications.

2-19 Currently, oversize aggregate for pit-run or grid-rolled material is defined as material:

(a) As shown in the Schedule of Items.

(b) Under 8 inches in diameter.

(c) That will not pass a 3-inch sieve.

(d) More than $\frac{3}{4}$ the depth of the layer.

2-20 Refer to the grading requirements for Grading BC-7 in figure 2-8. Would it be acceptable for 0 percent of the aggregate to pass the No. 200 sieve? _____

2-21 The results of a gradation test are shown below in terms of the cumulative percentage of aggregate passing each sieve. Fill in the blanks for the percentages between sieves.

Sieve Size	% Passing	% Between
$\frac{3}{4}$-in.	100	_____
$\frac{1}{2}$-in.	97	_____
No. 4	82	_____
No. 16	62	_____
No. 50	33	_____
No. 100	12	_____
No. 200	5	_____
Pan	0	_____

Quality. In addition to the source and gradation requirements, there are requirements for aggregate quality. By "quality" we are referring to determinations of aggregate physical and chemical properties other than gradation. These determinations--along with gradation--indicate the suitability of the aggregate for use in road construction.

As with gradation, the requirements for aggregate quality are based on how the aggregate is furnished. According to the FS Standard Specifications, aggregate furnished by pit-run or grid-rolling operations must be:

(1) Reasonably hard.

(2) Durable.

(3) Free of organic or other objectionable materials.

Durability tests--or other tests-- are not spelled out directly in the FS Standard Specifications. However, they may be in Supplemental Specifications or included by reference to other standards such as AASHTO. The Engineer should approve any minor variations in quality or organic content.

Aggregate furnished by crushing or screening operations must meet the requirements of Standard Specification Section 703.06, or as provided in the Special Project Specifications.

Many of the requirements shown in Section 703.06 of the FS Standard Specifications refer to AASHTO M 147, which lists the requirements for materials used in aggregate and soil-aggregate subbase, base, and surface courses. Special Project Specifications may also modify or add to the requirements. Simply stated, when the aggregate will be furnished by crushing or screening, you should thoroughly review the contract documents to determine all the requirements for aggregate quality.

Basically, the use of crushed or screened aggregate may require tests to determine:

(1) Liquid limit.

(2) Plastic limit and plasticity index.

(3) Amount of minus-200 material.

(4) Los Angeles abrasion (percentage of wear).

(5) Sand equivalent.

(6) Percentage of fractured faces.

(7) Durability index.

Let's discuss these briefly.

Liquid limit (L.L.) refers to the moisture content at which an aggregate material passes from a plastic (pliable but nonflowing) to a liquid state. It is determined by a standard test--AASHTO T 89. High liquid limits indicate soils of high clay content and low load-carrying capacity.

Plastic limit (P.L.) refers to the moisture content at which a soil changes from a semisolid to a plastic state. It is determined by AASHTO T 90. Like L.L., P.L. is influenced by the clay content of the aggregate material and is an indication of the material's load-carrying capacity. Reducing the moisture content below the P.L. leads to a rapid increase in load-carrying capacity; increasing the moisture content above the P.L. leads to a rapid decrease in the load-carrying capacity.

Plasticity index (P.I.) is the numerical difference between the L.L. and the P.L.--P.I. = L.L. - P.L. The difference represents the moisture content range within which an aggregate material (passing a No. 40 sieve) is plastic. Some specifications for aggregate surfacing require P.I.'s of between 4 and 9 to ensure that there is enough clay binder in the material. Some aggregate base specifications have a maximum P.I. requirement of 6 to ensure a clean, free-draining material.

The **amount of minus-200 material** in the aggregate affects the stability of the material. AASHTO T 11 is used to make this determination.

Los Angeles abrasion (percentage of wear) is a measure of the toughness of aggregate--its ability to resist abrasion and degradation. This is determined by the Los Angeles (L.A.) abrasion test (AASHTO T 96) and is expressed as the maximum allowable percentage of wear.

Sand equivalent represents the relative proportion of fine dust or claylike particles in aggregate material. It is determined by AASHTO T 176.

Percentage of fractured faces is the relative proportion of aggregate having one or more broken faces. The FS Standard Specifications for crushed aggregate base and surfacing require that at least 50 percent (by weight) of the particles retained on the No. 4 sieve must have at least one fractured face. The percentage of fractured faces is an indication of how well the aggregate particles will interlock and provide friction to form a stable base or surface course.

Durability index indicates the relative resistance of aggregate to degrading forces. It is determined by AASHTO T 210.

Besides being subjected to the aforementioned and other quality tests that may be designated, aggregate must always be inspected for organic materials and other undesirable substances.

SEGMENT QUIZ

2-22 Aggregate furnished by pit-run or grid-rolling operations, under the Standard Specifications, must be:

(a) Durable.

(b) Free of organic material.

(c) Tested for sand equivalent.

(d) Reasonably soft.

2-23 The specifications for crushed aggregate may require testing:

(a) Percentage of fractured faces.

(b) Viscosity.

(c) Los Angeles abrasion.

(d) Air content.

(e) Durability index.

2-24 What terms do the following initials stand for:

L.L. _____

P.I. _____

P.L. _____

The requirements for when and where to sample and test aggregate may vary from Region to Region and from contract to contract. Your concern, as always, is to learn the requirements for each job.

Preconstruction Investigation. In the planning or design phase of an aggregate base and surfacing project--before construction starts--source investigations are conducted. We referred to these earlier in the chapter. Source investigations include tests performed at the Central Lab on samples of material obtained from the pits.

These tests are performed to evaluate the quality of the aggregate in the proposed source. They include the Los Angeles abrasion test and the durability index test, tests not normally run in the field.

As an Inspector you should check the investigation reports to anticipate any problems with the aggregate on the job. A sample test report used in Region 1 is shown in figure 2-9. Let's look it over now.

Job Control Sampling and Testing. Once construction is under way, the aggregate must be sampled and tested for acceptability before it is incorporated into the work.

The crushing or screening plant must be equipped with sampling devices furnished by the Contractor. Usually, the Contractor will obtain samples of aggregates under the Inspector's supervision. At a crushing plant, these samples should be taken after the addition of any blending (filler or binder) materials.

The Forest Service must test the samples for such things as gradation and percentage of fractured faces. Satisfactory test results must be obtained before the aggregate is placed on the road.

Job control sampling and testing of aggregate will be your direct responsibility. As we mentioned, you must find out the sampling and testing frequencies for each job. An example of one Region's sampling and testing schedule is shown in figure 2-10.

NORTHERN REGION MATERIALS TESTING LABORATORY
U.S. FOREST SERVICE
Laboratory Test Data — Soils and Aggregates

FOREST	REPORT DATE
WHIS PAH	10/24/77
FIELD NO.	LAB NO.
D-67	10-73
PROJECT	
PINE PRAIRIE T.S.	

GRADATION — PERCENT PASSING

SIEVE SIZE	AS RECEIVED	LAB. CRUSHED	SPECS ITEM NO.	SPECS ITEM NO.
3 IN.	100			
1 1/2 IN.	98			
1 IN.	92			
3/4 IN.	85	100		
1/2 IN.	74	90		
3/8 IN.	64	79		
NO. 4	39	52		
NO. 8	28	39		
NO. 16	21	26		
NO. 30	16	20		
NO. 50	12	14		
NO. 100	11	13		
NO. 200	10.4	12.4		

LIQUID LIMIT 31, PLASTICITY INDEX 5

AASHO CLASSIFICATION _____

UNIFIED CLASSIFICATION _____

DESCRIPTION: GRAVEL

MOISTURE - DENSITY RELATIONS OF SOILS

AASHO T-99, METHOD _____

OPTIMUM MOISTURE _____ %

MAXIMUM DENSITY _____ P.C.F.

R - VALUE * _____

CONTROLLED BY EXPANSION ☐ EXUDATION ☐

TRAFFIC INDEX _____

REQUIRED GRAVEL EQUIVALENT COVER THICKNESS _____ IN.

* AN R-VALUE CONTROLLED BY EXPANSION MUST BE RECOMPUTED IF THE TRAFFIC INDEX CHANGES.

L. A. ABRASION, % WEAR 34 %

WASHINGTON DEGRADATION VALUE _____

STRIPPING TEST, ESTIMATED % COATED

W/O ADDITIVE +95 % ☐ -95 % ☐

WITH ADDITIVE +95 % ☐ -95 % ☐

DURABILITY INDEX

COARSE = 6

FINE = 28

FRACT. FACES, LAB CRUSH = 25%

REMARKS: UNACCEPTABLE FOR AGGREGATE BASE UNDER SS. 703.06 DUE TO LOW DURABILITY INDEX. WOULD ALSO HAVE PROBLEM MEETING MIN. FRACTURED FACES REQUIREMENT.

FORM NO. 81-7100 MTL 1 (9/71)

Figure 2-9.--Sample test report.

AGGREGATE SAMPLING AND TESTING SCHEDULE (Con.)

Material	Test	Test Method	Size Sample	Frequency
Crushed Aggregate for Surfacing and Base Course	Sieve Analysis	AASHTO T-11, -27	65 lb.	One dry sieve analysis and sand equivalent per 1,000 ton with at least two per shift. Run washed sieve analysis, sand equivalent, liquid and plastic limit and % fracture on one out of every three samples. At beginning of operation, more frequent wash tests are necessary to establish correlation with dry tests.
	Sand Equivalent	AASHTO T-176		
	Liquid Limit	AASHTO T-89		
	Plasticity Index	AASHTO T-90		
	% Fractured Faces	Special		
	Moisture-Density	AASHTO T-99	50 lb.	One test for each gradation and change in source if not too rocky for practical test.
	% Compaction and % Moisture	Balloon AASHTO T-205 Nuclear AASHTO T-238 and T-239	As required	One for each 1/2 mile single-lane or every 1,000 ton.
	CENTRAL LAB ONLY			
	Abrasion	AASHTO T-96	80 lb. for complete specification check	To verify previous aggregate source investigations, perform a minimum of one complete specification check per materials source prior to construction and as needed during construction when changes in materials source are apparent.
	Durability Index	AASHTO T-210		
	% Fractured Faces	Special		

Figure 2-10.--Sampling and testing schedule.

Notice that this schedule is divided into four test categories, covering gradation and quality, moisture-density relationships, percentages of compaction and moisture, and Central Lab quality tests. The first three categories are field tests for job control.

You should realize that frequencies such as these are considered the minimums for effectively controlling the aggregate material and the construction work. There are times when you should increase the frequencies:

(1) At the beginning of production you will ordinarily need to sample and test more frequently, continuing until production is uniform and under control.

(2) When conditions are unusual or the material varies considerably, increase the number of samples and tests as necessary to verify the uniformity of the aggregate and the required workmanship levels.

You may also need to send check samples to the Central Lab or to a private lab to be sure that the aggregate still meets the requirements of the quality tests, and to verify your own field test results.

Field sampling of aggregate may be done at several points: at the crusher or from conveyor belts, stockpiles, windrows, or the roadbed. The procedures for sampling and testing are covered in other Forest Service training courses.

Final Acceptance. Usually, the aggregate is accepted based on the results of test performed on samples taken at the crusher. However, the Forest Service reserves the right to sample and test for acceptance at a later point--for example, at the point of processing on the road--because of the possibility of problems such as contamination or segregation occurring during the hauling, placing, or spreading operations.

SEGMENT QUIZ

2-25 Crushing or screening plants must be equipped with sampling devices furnished by the _____.

2-26 Must aggregate test results be obtained before the aggregate is placed on the road? _____

2-27 Refer to the sample test report in figure 2-9. Which of the following explain why the tested material would be unacceptable?

(a) Too much lab-crushed material passed the No. 16 sieve.

(b) Did not meet the percentage of fractured faces requirement.

(c) Liquid Limit was only 31.

(d) Durability Index was too low.

2-28 According to the sampling and testing schedule in figure 2-10, how big should the aggregate sample be for field and quality testing? _____

2-29 According to the same schedule: If you are field testing the aggregate for gradation and sand equivalent, how many tests of each type should you run during one shift in which 1,350 tons of material are crushed? _____

2-30 When should you sample and test more often?

(a) When the aggregate varies considerably.

(b) At the beginning of production.

(c) When conditions are unusual.

(d) In the early afternoon.

2-31 List three places from which aggregate samples may be taken:

_____

_____

_____

Interpretation of Test Results. Interpreting test results is another of your important inspection responsibilities. By "interpretation," we mean comparing the test results with the specification requirements and being able to determine whether the aggregate meets or fails to meet these requirements.

This naturally involves the following steps:

(1) Performing the tests properly.

(2) Computing the results correctly.

(3) Determining the specification requirements.

(4) Comparing the test results with the requirements.

The sieve analysis worksheet in figure 2-11 shows not only the gradation test results, but it also shows the specification requirements ("Specification Gradation"). Look over the form and compare the results with the requirements.

Do the test results meet the requirements? Yes, they do. The aggregate may continue to be used--as far as gradation requirements are concerned. But what if the results of the sieve analysis--or of any other required test--failed? What should you do? We'll discuss your actions in a few minutes. But first, let's talk about keeping track of gradation test results.

Gradation Charts. The chief measure of the suitability of aggregate for use in base and surface courses is gradation. Since the Forest Service uses "end result" specifications, you are not responsible for inspecting the Contractor's equipment or methods of producing aggregate. Instead, you look at the end results of the operation--the aggregate itself.

As an Inspector you will see the results of many sieve analyses. Properly documenting these test values will help you to:

(1) Interpret the results of individual gradation tests.

(2) Relate the results of different tests to one another.

SIEVE ANALYSIS OF SOIL AND AGGREGATE

USDA, FOREST SERVICE, REGION 1

FOREST R.O. PROJECT MOOSE HORN ROAD 241.6

SAMPLE NO. 10 DATE 10-24-77

LOCATION STATION 407+60 - DENSE GRADED BASE COURSE

WEIGHT OF ORIGINAL SAMPLE 62.0 LBS.

Sieve Size	Weight Retained Individual	% Retained Individual	% Passing	Specification Gradation
3" (76.1mm)				
2" (50.8mm)				
1-1/2" (38.1mm)	0	0	100.0	100
1" (25.4mm)	9.0	14.5	85.5	
3/4" (19.0mm)	9.6	15.5	70.0	60-90
1/2" (12.7mm)	7.8	12.6	57.4	
3/8" (9.51mm)	6.6	10.6	46.8	
#4 (4.76mm)	5.4	8.7	(G) 38.1	30-50
Pan	23.6	38.1		
TOTAL	62.0	100.0		
Sieve Loss or Gain	±0			

Sieve Size	Weight Retained Individual	% Retained Individual	% Passing	Specification Gradation
#8 (2.38mm)	71.6	6.4	31.7	
#10 (2.00mm)	-	-	-	
#16 (1.19mm)	76.3	6.8	24.9	
#30 (595 u)	68.0	5.3	19.6	
#40 (420 u)	32.1	2.9	16.7	10-25
#50 (297 u)	25.7	2.3	14.4	
#100 (149 u)	33.5	3.0	11.4	
#200 (74 u)	38.5	3.4	8.0	3-15
Pan	(E) 90.0	8.0		
TOTAL	(H) 427.7			
Sieve Loss or Gain	(H-A) -0.3			

A Total Dry Weight Befor Washing — 428.0 GRAMS

B Total Dry Weight After Washing, Befor Sieving — 347.0

C Minus # 200 Washed Out (A-B) — 81.0

D Minus # 200 From Sieving — 9.0

E Total Minus # 200 (C+D) — 90.0

F Minus # 4 Correction Factor ($\frac{G}{H}$) — 0.08908

Material is Plastic [X] Non-Plastic [ ]

Form No. 51-7100-MTL-2 (8/72)	Operator	Checked By	Date 10-24-77

2-11.--Sieve analysis worksheet.

(3) Observe trends in gradation--even detect when the aggregate is headed out of gradation.

Let's look at some examples of the above.

When you receive the results of a sieve analysis (or compute the results of a test you yourself have run), what do you see?

Well, you see a series of sieve sizes with corresponding percentages (percentages of aggregate passing or between the sieves).

Sieve	% Passing
1½"	100.0
1"	85.5
¾"	70.0
½"	57.4
⅜"	46.8
#4	38.1
#8	31.7
#16	24.9
#30	19.6
#40	16.7
#50	14.4
#100	11.4
#200	8.0

Until you look at the gradation requirements, however, the test results mean very little. So you look at the range within which the test results must fall in order to pass. All this is shown in the table that follows:

Sieve	% Passing	Acceptable Range
½"	100.0	--
¾"	70.0	60 - 90
#4	38.1	30 - 40
#40	16.7	10 - 26
#200	8.0	3 - 15

You can compare the results of two or more tests by simply expanding the table:

Sieve	% Passing Test 1	Test 2	Test 3	Acceptable Range
½"	100.0	100.0	100.0	--
¾"	70.0	72.4	71.5	60 - 90
#4	38.1	39.3	39.2	30 - 50
#40	16.7	18.0	18.2	10 - 26
#200	8.0	9.1	8.6	3 - 15

However, figure 2-12 is a better way to document test values--one which allows you to do everything from noting individual test results to comparing many tests and observing trends.

Let's talk about the results of tests 1 through 14 shown in figure 2-12.

In all 14 tests, 100 percent of the aggregate passes the ½" sieve. The percentage of aggregate passing the ¾" sieve stays rather constant around 70, until a sharp drop after test number 8. The downward trend continues until test 11, when the percentage passing falls below the permissible range, to 58 percent. In subsequent tests, the percentage moves back up to around 70.

The other sieves show a similar downtrend between tests 7 or 8 and 11. None are beyond tolerance, however.

If you were the Inspector who kept this chart, you might have advised the Contractor of the downward trend as soon as you detected it. Some adjustment in the crushing or screening operations might have prevented the test failure.

Okay, this completes our discussion of the documentation of gradation test results. Now let's look at the actions you should take in the event of failing tests.

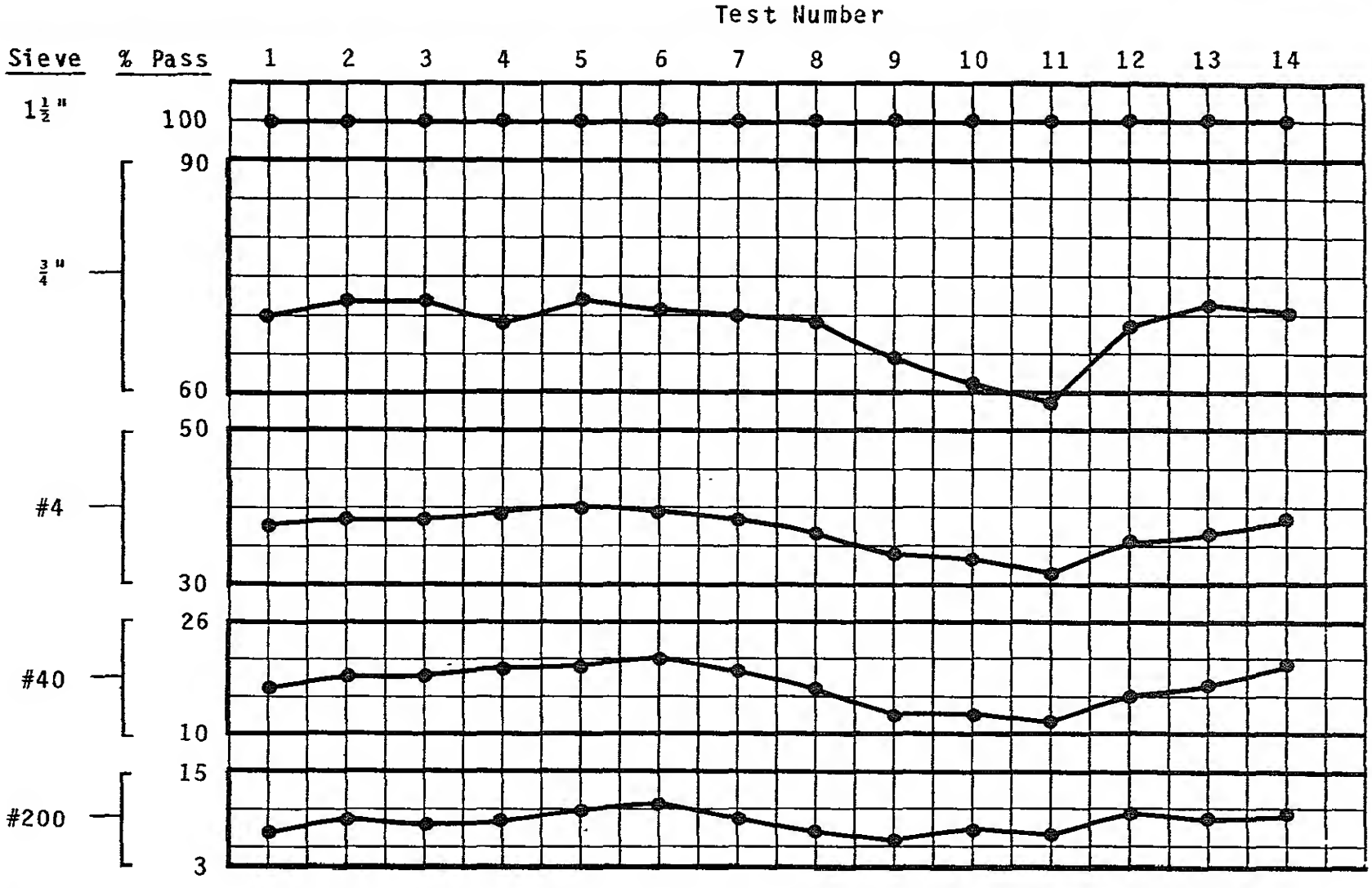


Figure 2-12.--Comprehensive documentation of gradation test results.

Actions in the Event of Failing Tests. When an operation fails gradation tests, you must be sure that the Contractor and Engineer are informed of how the aggregate failed to meet requirements. Be sure that the aggregate is not incorporated into the work until the Contractor can furnish material that meets all requirements. In other words:

(1) Inform the Contractor and Engineer.

(2) The Contractor should take corrective action--adjust crusher operations, work the pit in different manner, change filler or binder, or some such.

(3) New samples should be obtained and tested.

(4) Results should be verified as meeting requirements before you allow the Contractor to use the aggregate.

When the failing tests are ones that you yourself performed, first follow these steps:

(1) Check your calculations. You may have made a math error or simply a mistake in documentation.

(2) If the computations were correct, run another test on the initial sample OR get a new sample and test it--depending on whether or not you think you made a mistake in test procedure.

(3) If the check test results also indicate failure, inform the Contractor and Engineer. Again, corrective actions must be taken and the material must be retested and verified as acceptable before it can be used.

Sieve Designation	Percent Passing AASHTO T 11 and T 27				
	Grading A	Grading B	Grading C	Grading D	Grading E
3 inch	100				
2 inch	65-95	100			
$1\frac{1}{2}$ inch			100		
1 inch		60-90		100	
$\frac{3}{4}$ inch	40-75		60-90	70-98	100
$\frac{1}{2}$ inch		44-70			70-98
No. 4	22-45	28-50	30-55	36-60	44-70
No. 8	16-34	20-41	22-43	25-47	30-54
No. 30	8-22	9-26	11-27	12-31	15-34
No. 200	2-10	3-12	3-15	3-15	3-15

2-32 Suppose you are running sieve analyses on aggregate that must meet the requirements of Grading C shown in the table above. Results for one test are:

Sieve	% Passing	Sieve	% Passing
$1\frac{1}{2}$"	100	#8	25
$\frac{3}{4}$"	73	#30	8
#4	31	#200	2

Does the aggregate pass or fail?

WATER

As we said earlier, water is an essential ingredient in the construction of aggregate base and surface courses. There are no quality requirements.

Suitable and adequate water sources may be indicated on the drawings. The Contractor who chooses to obtain water from a source other than the one designated is responsible for obtaining the right to use that water.

Always check the Special Project Specifications to learn of any additional water requirements.

FILLER & BINDER

Fillers and binders are mineral materials which may be added to improve the aggregate. Briefly stated, fillers are added to improve the gradation of the aggregate and binders are added to increase the cohesiveness or binding quality of the aggregate.

Clay is a common binder. For example, sand-clay bases are often constructed in areas with abundant sand. The sand alone is too loose and nonplastic to form a well compacted, stable material. So clay is added as a binder.

Fillers or binders are added only when sufficient quantities are not naturally present in the aggregate. When needed, they must meet all requirements and be obtained from sources shown on the drawings or in the Special Project Specifications.

Fillers and binders must be uniformly blended with the aggregate. For pit-run or grid-rolling operations, filler must be added on the road. For crushing and screening operations, the filler should be blended at the plant during the crushing or screening.

CHEMICAL ADDITIVES

Chemical additives--calcium chloride, sodium chloride, magnesium chloride, or hydrated lime--may be added to aggregate to control dust (palliative), to lower a high P.I. condition, or to furnish binder.

Any of the above additives required in the aggregate must meet the AASHTO or ASTM specification indicated in section 712 of the Standard Specifications.

Test reports or manufacturers' certifications should accompany shipments of chemical additives. The material may be delivered in bulk shipments or in sacks and will usually be added to the aggregate in stationary plants.

Cement-treated and bituminous-treated bases are somewhat related to lime-treated bases in that all are types of stabilized base courses.

CHAPTER QUIZ

2-33 For Government-designated sources, who must determine the equipment and work methods to produce aggregate that meets requirements?

(a) Government.

(b) Contractor.

(c) Inspector.

(d) Crusher operator.

2-34 For grid-rolling, pit-run, and screening operations, the Contractor should use all suitable material that can be reduced to:

(a) A diameter of 12 inches or less.

(b) $\frac{2}{3}$ the diameter of the largest size aggregate.

(c) Plus-16 material or smaller.

(d) As shown on the Schedule of Items.

2-35 The Contractor should observe the quarry safety requirements of OSHA and _____.

2-36 "Relative distribution" is a term which can be used in defining:

(a) The arrangement of sieves in a stack.

(b) The locations of equipment in an aggregate pit.

(c) Aggregate gradation.

(d) The geographic whereabouts of your kin.

2-37 A No. 8 sieve has:

(a) 8 openings per linear inch of mesh.

(b) 8 rows of 8 openings in each sieve (a total of 64 openings).

(c) Round openings only.

(d) Openings 0.8 inch square.

2-38 Refer to the requirements for Grading BC-5 in figure 2-8. Would 56 percent passing a $\frac{1}{2}$-inch sieve be acceptable? _____

2-39 Resistance to abrasion can be measured by:

(a) The sand equivalent test.

(b) Exposure to hydrated lime.

(c) The 5-point proctor test.

(d) The L.A. abrasion test.

2-40 You subtract the P.L. from the L.L. to get the:

(a) L.P.

(b) Durability Index.

(c) Plasticity Index.

(d) Minus-200 material.

2-41 Where should sampling for aggregate testing take place?

(a) At the road, after spreading but before compaction.

(b) From the windrow after processing.

(c) At the crusher.

(d) From the haul truck.

2-42 According to the schedule in figure 2-10, how often should aggregate be sampled to test for durability?

(a) Once per roadway mile.

(b) Once per shift, and when changes are apparent.

(c) Once per source, and when changes in material in the source are apparent.

(d) Twice per day, with an extra sample taken on rainy days.

2-43 Do the L.L. and P.I. results on the form in figure 2-9 meet the requirements of Standard Specification 703.06 (1985) for surfacing? _____

2-44 You should sample and test more often when the aggregate varies considerably. List two other times when you should sample and test more frequently.

_____

_____

2-45 In which order should you do the following steps when your own job control test fails?

_____ Run another test.

_____ Check calculations.

_____ Inform Contractor and Engineer.

2-46 Refer to the table on page 2-35. You are inspecting a job in which Grading D aggregate is used. The results of one gradation test are:

Sieve	% Passing
1"	100
$\frac{3}{4}$"	92
No. 4	51
No. 8	38
No. 30	26
No. 200	11.7

Does the aggregate represented by this test meet the gradation requirements? _____

2-47 Match the following.

_____	(a) Chemical additives.	(1)	Dust palliative.
_____	(b) Binders.	(2)	Improves gradation of aggregate.
_____	(c) Fillers.	(3)	Improves cohesion of aggregate.

2-48 When crushed aggregate is used, any required filler should be blended:

(a) First with water, then added to aggregate.

(b) In the windrow.

(c) During the crushing.

(d) Just before compaction.

2-49 The chief measure of aggregate suitability for base and surfacing is _____.

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(a) Once per roadway mile.

(b) Once per shift, and when changes are apparent.

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(a) First with water, then added to aggregate.

(b) In the windrow.

(c) During the crushing.

(d) Just before compaction.

2-49 The chief measure of aggregate suitability for base and surfacing is _____.

2-50 Refer to the gradation chart in figure 2-12. In test number 8, the percentage of aggregate passing the #40 sieve was:

(a) About 24 percent.

(b) 21.5 percent.

(c) Approximately 17 percent.

(d) Nearly 37 percent.

2-51 Gradation charts can be used to:

(a) Observe trends in the gradation of the aggregate.

(b) Interpret the results of individual gradation tests.

(c) Determine the exact cause of tests failure.

(d) Relate the results of different tests to one another.

You are finished with chapter 2. Before you begin chapter 3, however, take a minute to scan this chapter. Did you understand everything? Are there any sections that seem vague to you? Review until you're confident about what you learned. Go on to chapter 3 when you're ready.

CHAPTER 3
INSPECTING the ROADBED

Aggregate base and surface courses must be constructed on foundations that have been properly constructed. The foundation for the surface course is the base course, and the foundation for the base course is either the subbase or the subgrade. If these terms and what they represent are not clear in your mind, turn back to chapter 1 and review pages 1-1 through 1-3.

You might ask, "What difference does it make if the foundation is not built properly, as long as the base or surface course is well constructed?" Well, it makes a lot of difference. Regardless of how well the overlying course may be constructed, serious defects in the base or subgrade will weaken the entire road structure.

In this chapter we will talk about how you can ensure that the subgrade or base is adequately prepared. By the end of the chapter you should:

(1) Be able to determine from the contract documents the requirements for roadbed preparation.

(2) Know which tests and inspections to perform on roadbeds, as well as when to perform them and how to use test results.

(3) Know what actions to take in case of noncomplying roadbeds.

Your responsibilities in this area depend, to some extent, on what work is included in the contract. There are two basic cases:

(1) Where the base and surfacing are included in the same contract with the excavation and embankment.

(2) Where the base or surfacing is constructed on an existing subgrade or base course.

Where aggregate base or surface course construction is included in the same contract as the excavation and embankment work, excavation and embankment requirements include preparing the roadbed. This doesn't mean, however, that you should assume the subgrade has been properly prepared and is in good condition. Months may have passed since the roadbed was finished, subjecting the subgrade to the effects of traffic and weather. Or inspection of the finished roadbed may simply have been incomplete and failed to turn up defects.

Sometimes, aggregate base or surfacing is constructed under a separate contract--on an existing subgrade or base course. This often means that a much longer time has passed and the effects of traffic and weather have taken their toll on the roadbed. "Reconditioning Existing Road" (Standard Specification 306) is frequently called for in these cases. This work item involves scarification of the roadbed surface as designated in the drawings and marked on the ground. It may also include compaction.

In any case, you should know the requirements for the roadbed and the inspections you need to perform to ensure that they have been met.

CONTRACT REQUIREMENTS

The Standard Specifications (1985) say the following concerning the preparation of roadbed for aggregate base and surfacing:

> The roadbed shall be completed in accordance with section 203 or 306 and approved in writing by the Engineer before placing base or surface course.

Since this is not a training course in excavation and embankment, we will not go into detail about roadbed construction and preparation. But let's look briefly at the standard requirements for finishing the roadbed. We'll discuss approval at the end of the chapter.

(1) For roads receiving aggregate base or surface course, only rocks that do not protrude above the subgrade more than one-third of the depth of the base or surface course, or 3 inches, whichever is less, may remain in place.

(2) For unsurfaced roads, unless otherwise SHOWN ON THE DRAWINGS, the top 4 inches below the finished road surface shall not contain rocks larger than 4 inches in greatest dimension. Oversize

material shall be removed, reduced to acceptable size, or covered by importing suitable material approved by the Engineer.

(3) The subgrade shall be visibly moist during shaping and dressing. Low sections, holes, cracks, or depressions shall be brought to grade with suitable material approved by the Engineer. Final compaction of the subgrade shall meet the requirements of the embankment placing method specified.

We can summarize the preceding requirements into the following list:

(1) Line.

(2) Grade.

(3) Cross Section.

(4) Density.

(5) Condition.

Your inspection of the roadbed prior to placing the aggregate should include verification of each of these items. We will discuss them after you take the quiz.

SEGMENT QUIZ

3-1 Should you inspect the subgrade before aggregate base construction begins if the excavation and embankment and the aggregate base and surfacing are included in the same contract? _____

3-2 Rocks that do not protrude above the subgrade more than $\frac{1}{3}$ of the depth of the base course, or _____ inches, whichever is less, may remain in place.

3-3 For unsurfaced roads, the top ____ inches below the finished roadbed surface must consist of cushion material containing rock less than ____ inches in greatest dimension.

3-4 Which of the following are among the requirements for finishing subgrade?

(a) Proper line.

(b) Correct grade.

(c) Cross sections as per typical sections on drawings.

LINE, GRADE, & CROSS SECTION

The line, grade, and cross sections, as designed, are indicated on the drawings. In the field they are established, controlled, and checked by reference to stakes.

You should already be familiar with the reading and interpretation of drawings, so let's quickly look at some sample plan and profile views and a typical section.

Drawings

An excerpt from a plan view of a proposed forest development road is shown in figure 3-1. It shows the horizontal alignment of the roadway, indicating station numbers, points of curvature and tangency, degrees of curvature, locations of two CMP, right-of-way limits, turnouts, and such physical features as an existing fence and a rock outcrop.

Look over figure 3-1 for a minute, then continue.

An excerpt from a profile view of basically the same section of road is shown in figure 3-2.

(1) The vertical scale is larger than the horizontal scale to emphasize the grade.

(2) The bold line is the subgrade profile. A finer line indicates the existing ground line.

(3) The percentages of grade are shown, as well as the lengths of the vertical curves.

(4) The locations of turnouts and the corrugated metal pipes are indicated.

Notice that the locations of two temporary bench marks (TBM) are shown at the top of the profile view. The roadway grade--and the stakes--are referenced to these TBM's.

A typical section from the drawings is shown in figure 3-3. It shows you the width of the traveled way and shoulders, typical slope rates, clearing limits, original ground line, and the compacted widths of the base course. Note that some sections of the base course will be 8 inches thick and some will be 12 inches thick. The base is to be compacted in 4-inch lifts.

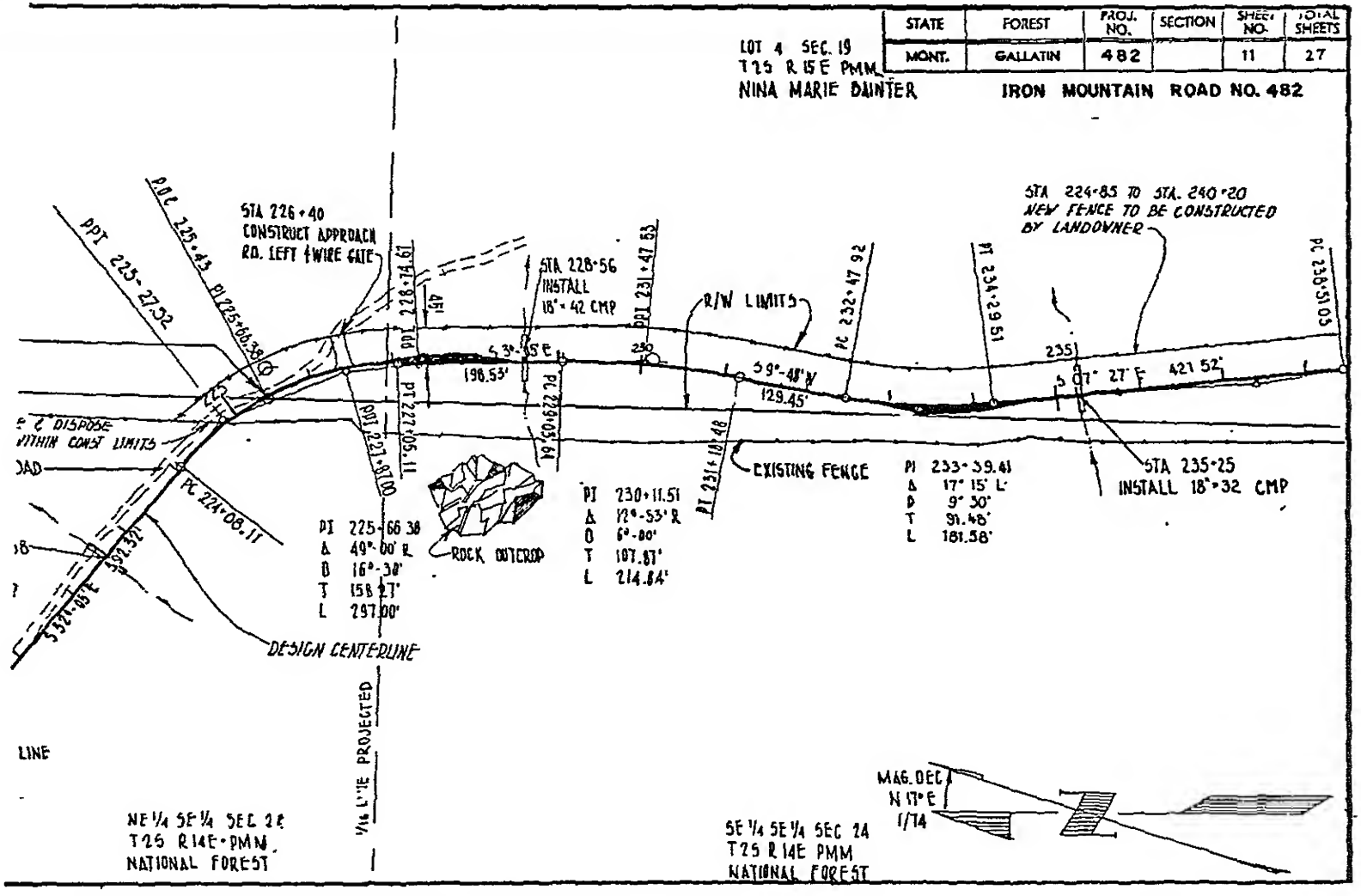


Figure 3-1.--Plan view of a proposed forest development road (excerpt).

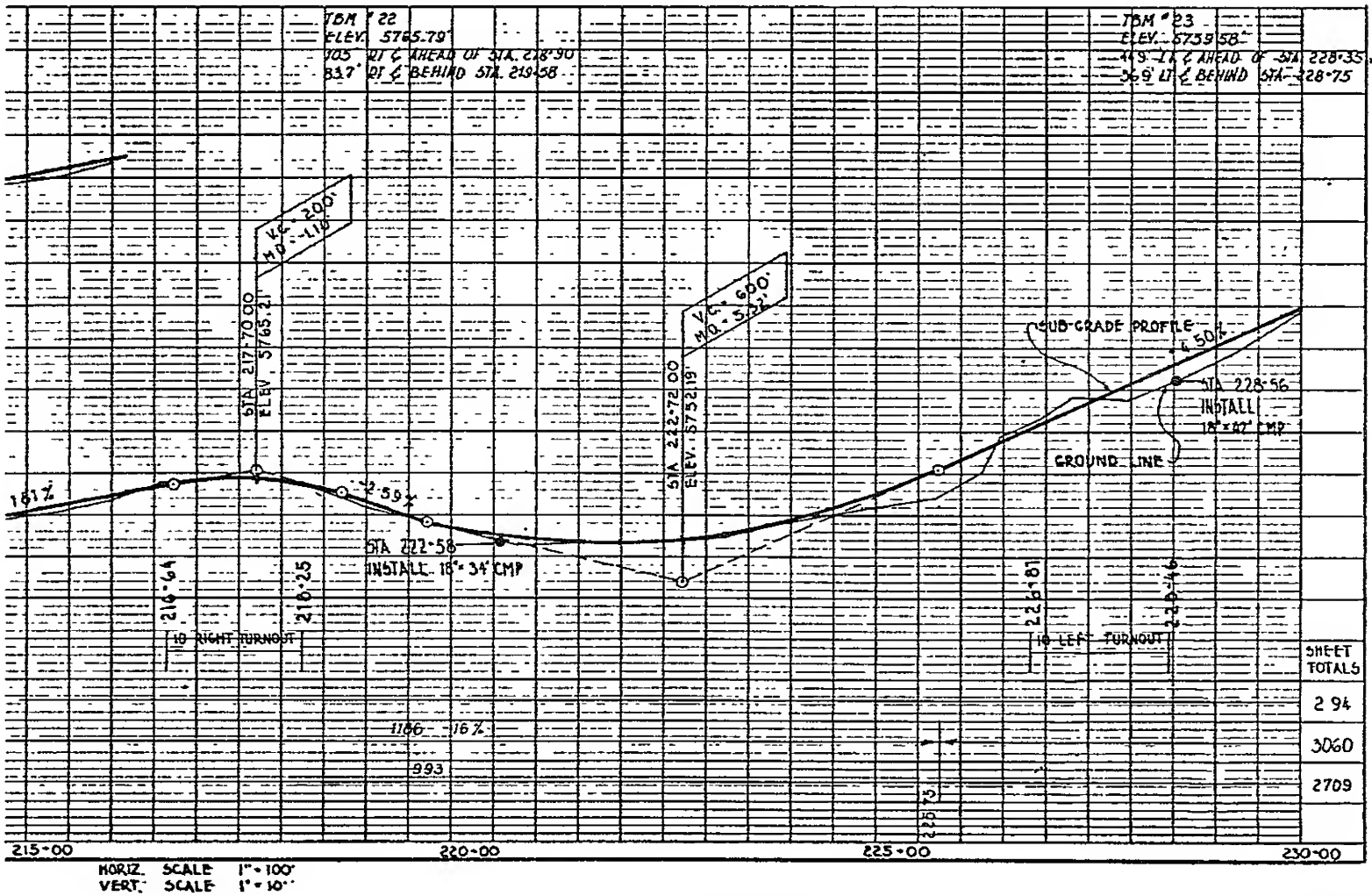


Figure 3-2.--Profile view of a proposed forest development road (excerpt).

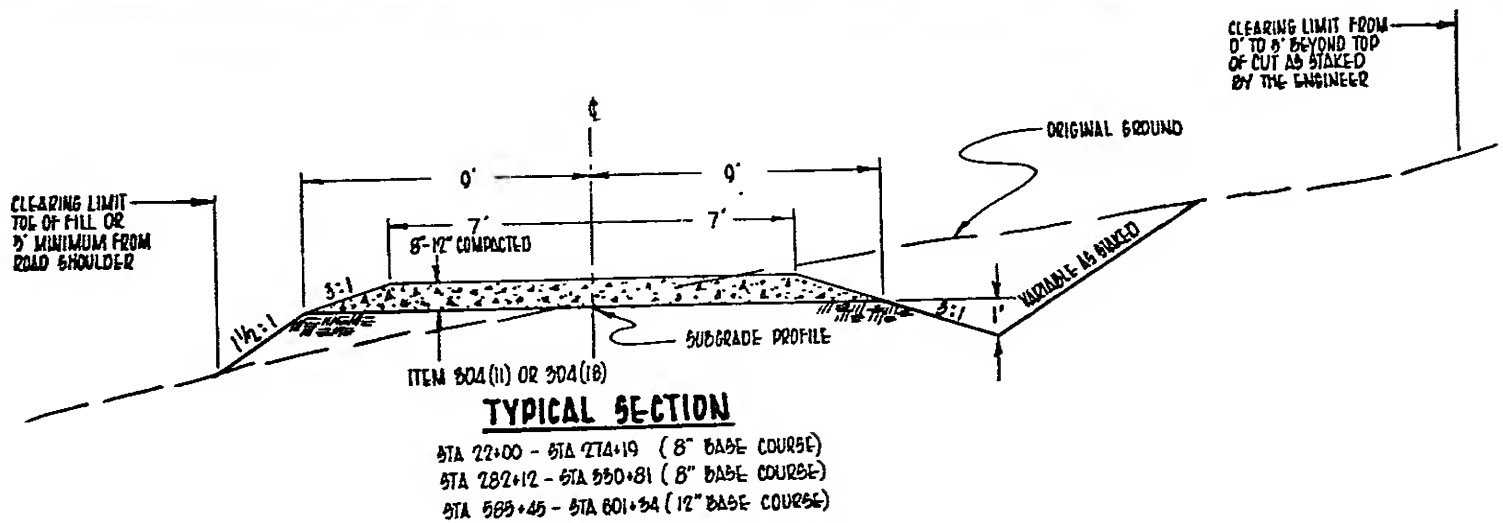


Figure 3-3.--Typical section of proposed road plan.

SEGMENT QUIZ

3-5 Roadway lines, grades, and cross sections are shown in:

(a) The Special Project Specifications.

(b) Summary and Schedule of Items sheets in the drawings.

(c) The General Provisions.

(d) Plan, profile, and typical section sheets of the drawings.

3-6 Match the sources of information on the left with the items on the right.

(a) Plan view.

(b) Profile view.

(c) Typical section.

_____ (1) Existing (or original) ground line.

_____ (2) Lengths of vertical curves.

_____ (3) PC's and PT's.

_____ (4) Horizontal alignment.

_____ (5) Base course thicknesses.

Staking

It would be impossible to construct roadways directly from the drawings. Stakes are set by Forest Service or contract survey crews as references for line and grade. Figure 3-4 shows a typical cross section and the stakes that would be placed to guide construction operations for a typical aggregate-surfaced road.

The centerline stake would be removed during excavation. The control stake for base and surfacing would be set before base construction begins to provide closer control of line and grade. The stakes are typically marked as shown in figure 3-5. Study the markings thoroughly.

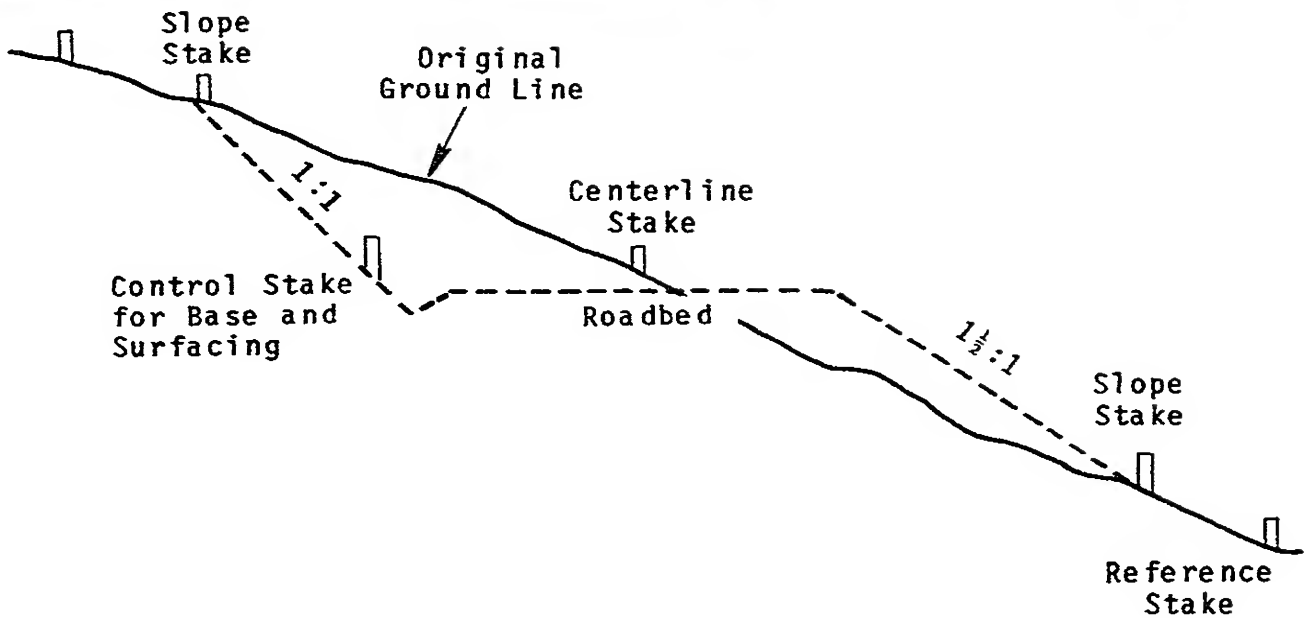


Figure 3-4.--Cross section and stake placement for a typical aggregate-surfaced-road.

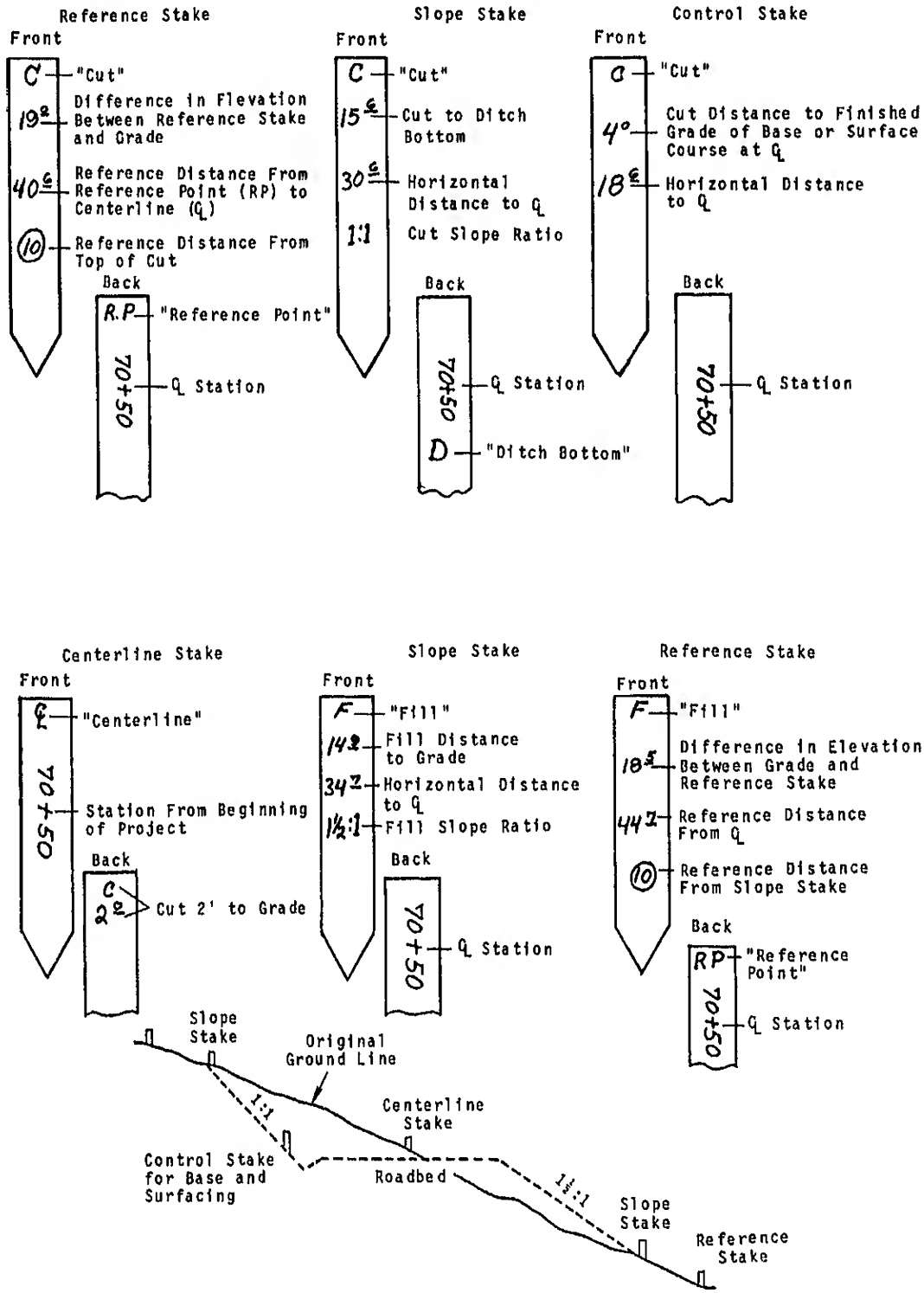


Figure 3-5.--Stake markings in planned road construction.

Could you follow the sample markings? Here are some other points concerning standard stake markings:

(1) The fronts of centerline stakes face the beginning of the project. Reference, grade, slope, and control stakes face the centerline.

(2) Grade is measured from the point where the groundline intersects the stake.

(3) Reference stakes at the toes of fills are optional.

(4) RP's (reference points) always refer to the grade at centerline when D, S, or HP (hinge points) are not shown.

(5) D must be shown when the cut refers to the ditch bottom. HP must be shown when the slope stake refers to the hinge point. S must be shown when the slope stake refers to the inside of the shoulder.

The sample control stake for aggregate base and surfacing is one way of controlling line and grade of the aggregate courses. But there are other ways. For example, "blue tops" may be used as shown in figure 3-6--when the road will subsequently be paved.

The grade stakes are referenced to the finished subgrade and are used in guiding the subgrade operations. To guide the base course

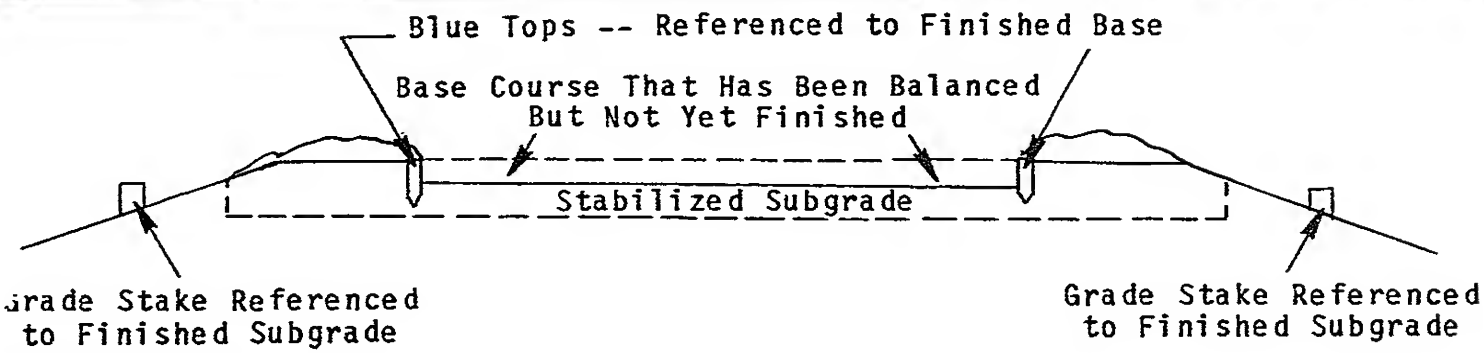


Figure 3-6.--Use of blue tops in preliminary road layout.

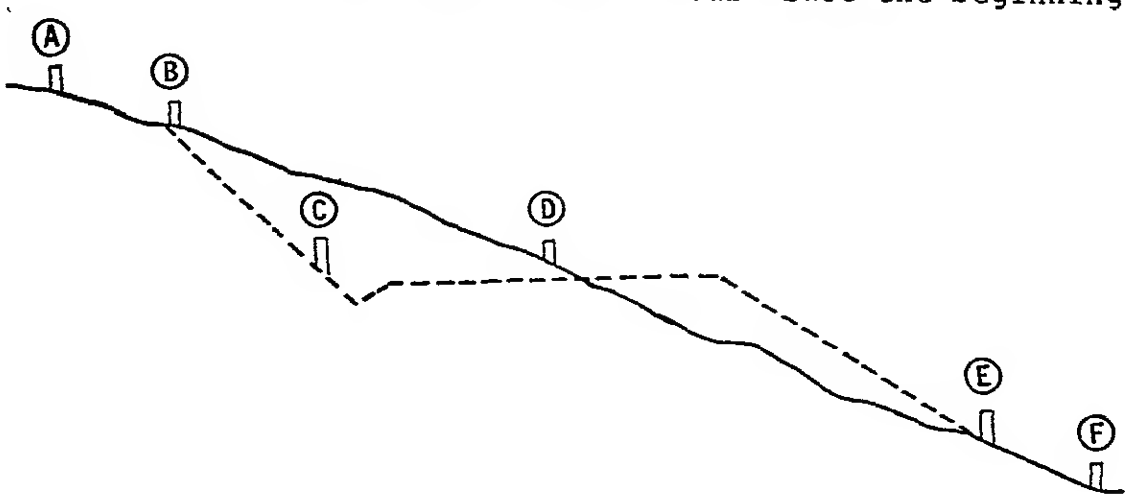
construction, blue tops are then set after the base material is placed and balanced. They are referenced to the top of the finished base course. The blue tops may be set on the edge of the base--as shown below--or may be offset, for example, 1 foot.

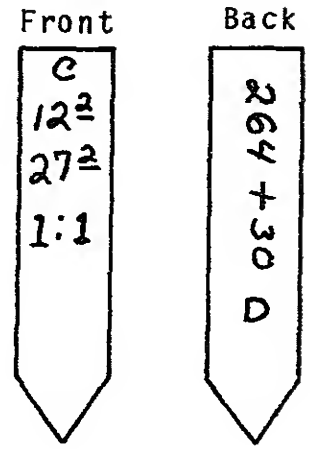
Blue tops are often covered up during construction and must be exposed in order for the motor grader operator to just clip over the top.

SEGMENT QUIZ

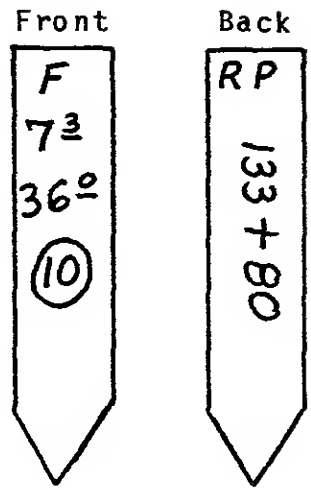
3-7 Where would the stake shown below (on the right) be set in the illustration below? _____

3-8 Which stake should face the beginning of the project? _____





Answer questions 3-9 through 3-11 by referring to the stake shown below.



3-9 What type of stake is this?

(a) Control stake for aggregate base.

(b) Centerline stake.

(c) Blue top.

(d) Reference stake.

3-10 What is the horizontal distance from the stake to the $\mathbb{Q}$? _____

3-11 What does the "$7\frac{3}{-}$" indicate?

(a) Fill height from stake to grade.

(b) Horizontal distance from stake to shoulder line.

(c) Difference in grade between this stake and slope stake.

(d) Reference distances from slope stake.

Checking Line, Grade, & Cross Section

Using the drawings and available stakes, you should be able to check the line, grade, and cross section of the subgrade or base course. Keep in mind, however, that actual construction may depart from the design. For example, the grade may have been adjusted slightly by the Engineer to balance the earthwork.

Normally, most of your checking will be by eye--observing the line, grade, and cross section of the roadbed to see if it has been constructed as staked and as designed in the drawings. This can be done with reasonable accuracy.

You should watch especially for proper crown and superelevation. Gross deviations from the correct crown and superelevations will certainly become evident in the finished aggregate base or surface course.

At times you will want to make more exact checks. Using the stakes, you can employ such inspection tools as a measuring tape, level and level rod, or stringline to pinpoint the actual line, grade, and cross section of the roadbed. Some simple examples are shown in figure 3-7.

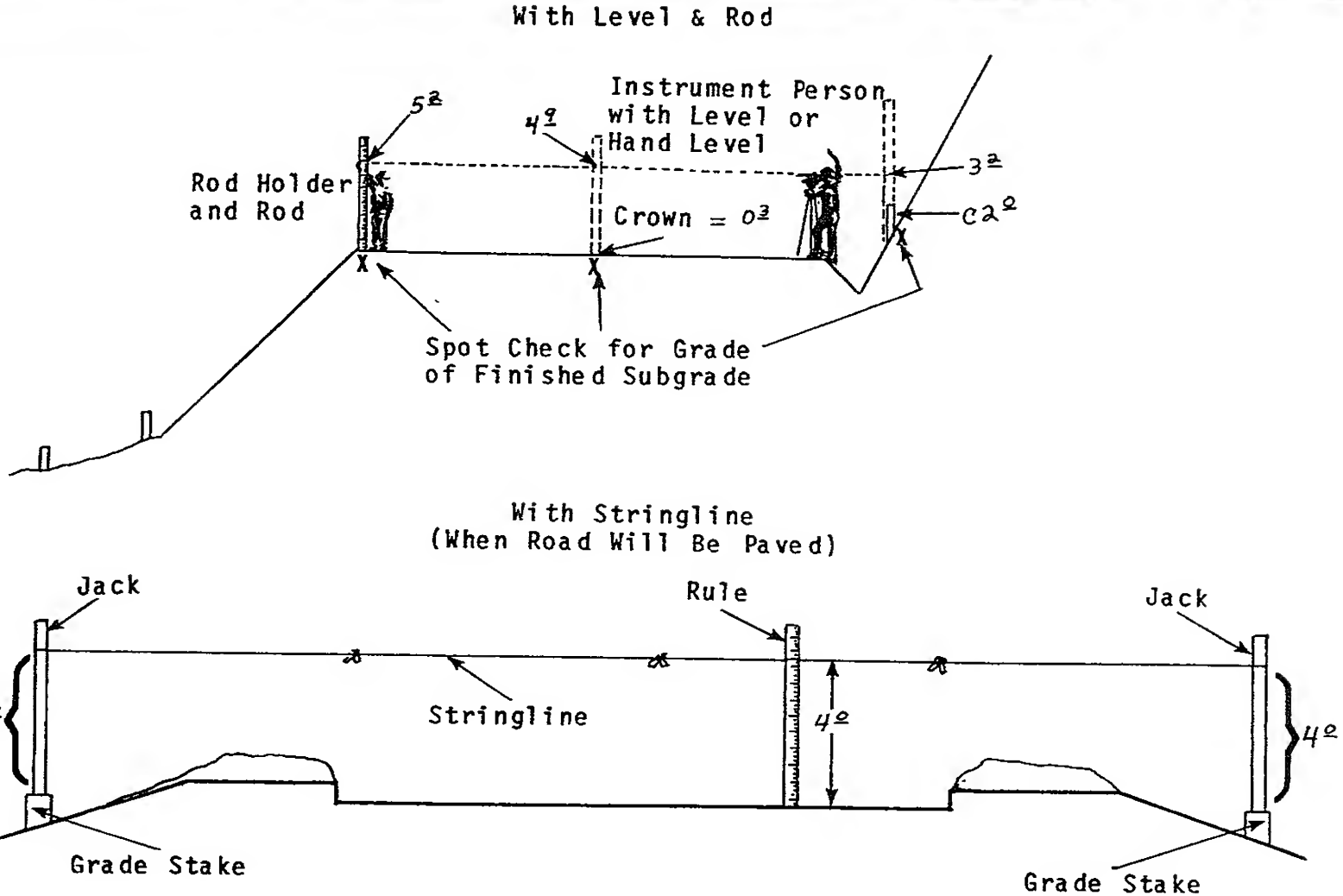


Figure 3-7.--Checking subgrade.

DENSITY

It is very important for the finished roadbed to have adequate density. Density problems in the roadbed can lead to failures in the aggregate base or surfacing.

As with line, grade, and cross sections, most of your checking for roadbed density will be done by eye. Areas without sufficient density will often appear soft and spongy. You can check this further by probing with a stake or other tool to detect loose subgrade.

When there are serious doubts as to roadbed density, density tests should be run to determine the degree and extent of the deficiencies. However, remember that the Inspector or Engineer cannot require the Contractor to obtain certain densities unless the contract includes such a specific requirement.

CONDITION

Finally, you should observe the general roadbed condition before aggregate base or surfacing operations begin. The overall requirements for proper line, grade, cross section, and density may be met, and yet the roadbed may still be in poor condition with ruts, potholes, bumps, spongy areas, or oversized and otherwise unsuitable material. Figure 3-8 shows what we mean by unacceptable conditions.

Subgrade yielding--known as pumping--may be observed when haul trucks cause the ground to undulate, bringing water to the surface.

Small areas of pumping should be corrected by removing or drying the wet materials, adding similar materials if necessary, and compacting the corrected areas.

Unsuitable subgrade materials should be removed and replaced with suitable material. The corrected area should be brought to the specified moisture content and then compacted to the required density.

Overall, the subgrades should have a uniform appearance conforming to the required lines, grades, and cross sections, and with adequate density.

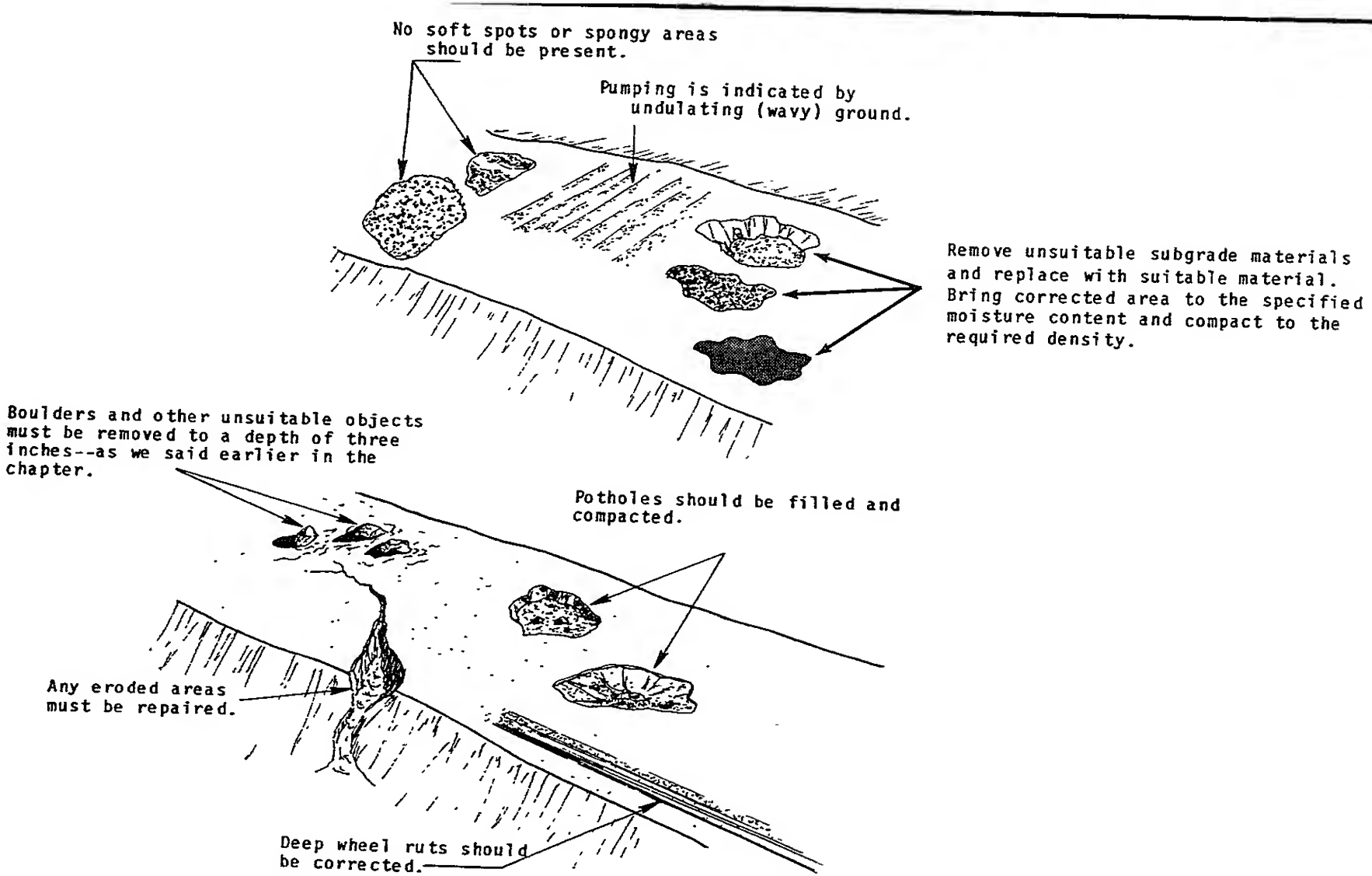


Figure 3-8.--Unacceptable road conditions.

SEGMENT QUIZ

3-12 Normally, most of your checking for line, grade, cross section, and density will be by:

(a) Eye.

(b) Transit.

(c) Actual test procedure.

(d) Straightedge.

3-13 When checking for line, grade, and cross section, you should watch especially for proper _____ and _____.

3-14 Which of the following should be used when checking the line, grade, and cross section of roads which will be paved?

(a) Rolling straightedge.

(b) Stringline.

(c) Level and level rod.

(d) Nuclear gauge.

3-15 If you have serious doubts that a certain area of the roadbed meets density requirements, you should:

(a) Issue a stop order.

(b) Drive over it a few times to better compact it.

(c) Run density tests.

3-16 Undulating--wavy--ground may indicate:

(a) Pumping.

(b) The presence of oversize materials.

(c) Too much

finished roadbed?

ACTION TO BE TAKEN

Turn back to the Contract Requirements section (page 3-2) for a moment and read the quotation from the Standard Specifications.

The roadbed must be ". . . approved before placing base or surfacing course." So what should you do after you inspect the roadbed?

Well, if there are unacceptable conditions, you must notify the Contractor and the Engineer. Such conditions must be corrected before any aggregate is placed.

If the roadbed is acceptable, approval will be given by the Engineer for the Contractor to begin construction.

An example of a written approval--or "notice to place"--is shown in figure 3-9. Note that the form is for timber sale contracts. Read the form, then take the last quiz of the chapter.

TION
CE

1. SALE	2. CONTRACT NUMBER
PINE PRAIRIE	01816-6
	3. CONTRACT DATE 8/6/77

4. TO (Purchaser)	5. FOREST	6. PROJECT
SUGAR PINE LUMBER CO.	WHIZPAH	ROAD NO. 5211
	7. DISTRICT WEPPE	8. AGREEMENT AND/OR NOTICE NO. 3 DATE 6/3/78

INSTRUCTIONS: Use this form when it is desirable to document any agreement or communication with the purchaser relative to the construction of specified roads. This form should also be used when road specification require written approval.

This document is issued for the following reason:

☐ Non-compliance with the requirements of Drawings and/or Specification No. _____

☒ Approval* or authorization as called for in Specification No. 304

☐ Mutual agreement as authorized in Specification No. _____

☐ Minor design change agreements not qualifying for cost adjustment. _____

THE ROAD BED AND SHOULDERS HAVE BEEN PROPERLY CONSTRUCTED, PREPARED AND FINISHED. APPROVAL, AS REQUIRED IN SUBSECTION 304.08, IS GIVEN FOR PLACING BASE COURSE.

*Approval as used herein relates to those Specifications which require Forest Service approval for a given work item. It does not mean final approval of construction under B.6.35, Acceptance of Work.

NAME AND SIGNATURE	TITLE	DATE
JIM DANDY	ENGINEERING REPRESENTATIVE	6/3/78
I acknowledge receipt of this document	I agree on behalf of purchaser (delete if inapplicable)	
John Doe	PURCHASER'S REPRESENTATIVE	6/3/78

DISTRIBUTION:
ORIGINAL TO PURCHASER, 1 COPY EACH TO: SO, RD, ER, AND PURCHASER'S REPRESENTATIVE.

7700-42 (10/71)

☆ U.S. GOVERNMENT PRINTING OFFICE : 1972-724-398/184 3-1

CHAPTER QUIZ

3-18 The Standard Specifications require that boulders be removed to a depth of at least _____ below subgrade within the limits of the roadbed.

3-19 Where in the contract documents will you find the points of curvature and the points of tangency for a road?

(a) In the Supplemental Specifications.

(b) On plan views from the drawings.

(c) In the typical sections.

(d) Under the Summary of Items.

3-20 In what direction should reference stakes face?

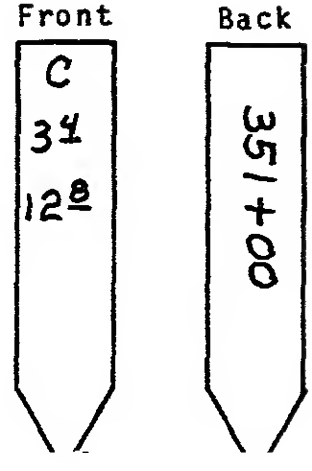
(a) Toward the project centerline.

(b) Due north.

(c) Toward the beginning of the project.

(d) It doesn't matter.

3-21 Referring to the control stake markings below, what does the "3$\frac{4}{}$" mean?



(a) Horizontal distance to the ditch line.

(b) 3.4 feet to R.P.

(c) Vertical distance from stake to grade at centerline.

(d) Horizontal distance to centerline.

3-22 The "12$\frac{8}{}$" is the:

(a) Horizontal distance from stake to shoulder line.

(b) Horizontal distance from stake to centerline.

(c) Vertical distance from stake to toe of slope.

(d) Vertical distance from stake to grade at centerline.

3-23 Which of the following is typically used for controlling the base course construction of aggregate-surfaced roads?

(a) Blue tops.

(b) Centerline stakes.

(c) Slope stakes or control stakes set from slope stakes.

(d) Probes.

3-24 What should be used for exact checking of line, grade, and cross section of roads that will be paved?

(a) Volumeter.

(b) Hand level.

(c) Visual observation.

(d) Stringline.

3-25 The contract requires a specific roadbed density. If you see an area of the roadbed that looks soft and spongy--and feels loose when you probe it--what should you do next?

(a) Run a density test.

(b) Ignore it if it's the only noncomplying spot in the roadbed.

(c) Point it out on a "notice to place" form.

(d) Order the Contractor to compact the are(a)

Go on to chapter 4 when you are ready.

CHAPTER 4
INSPECTING AGGREGATE PLACEMENT

In this chapter we will study your inspection duties related to placing the aggregate on the prepared subgrade or base course. We'll talk about the requirements for aggregate stockpiling, hauling, dumping, mixing, and spreading.

By the end of this chapter, you should:

(1) Be able to determine from the contract documents and other sources the requirements, methods, and sequences for hauling, stockpiling, spreading, and mixing the aggregate.

(2) Be able to interpret the drawings and Special Project Specifications to know the details of spreading the aggregate: number of courses, width and thickness of spread, and so forth.

(3) Know the importance of determining the Contractor's plan of operation and equipment for hauling, spreading, and mixing the aggregate.

(4) Know how to use staking or other methods to control the aggregate's line, grade, and spread.

(5) Be able to inspect the Contractor's hauling and dumping operations.

(6) Be able to inspect the Contractor's stockpiling of aggregate.

(7) Be able to inspect the Contractor's spreading and mixing operations--by the road-mix method.

(8) Be somewhat familiar with other types of mixing operations, for instance travel plant and stationary plant.

(9) Know the actions to take in case of Contractor noncompliance in hauling, dumping, spreading, mixing, and so on.

Okay, let's get started by looking first at the contract requirements.

CONTRACT REQUIREMENTS

We can briefly state aggregate placement contract requirements this way: aggregates of the specified gradation and quality must be mixed uniformly (along with any required additives) at the required moisture content, placed on the subgrade or base course and spread to the required line, width, and thickness. When multiple layers are called for, each must be shaped and compacted before the succeeding layer is placed.

The Standard Specification requirements appear below.

> 304.09 Mixing and Placing
>
> Unless otherwise specified on the drawings or in the Special Project Specifications, the Contractor may mix the material and any additives required by any one of the three following methods:
>
> (a) Stationary Plant Method. The aggregate and water shall be mixed in an approved mixer. Water shall be added during the mixing operation in the amount necessary to provide the moisture content for compacting to the specified density. After mixing, the material shall be transported to the job site while it contains the proper moisture content and shall be placed on the subgrade or base by means of an aggregate spreader.
>
> (b) Travel Plant Method. After the material for each layer has been placed through an aggregate spreader or windrow sizing device, the material shall be uniformly mixed by a traveling mixing plant. During the mixing, water shall be added in an amount sufficient to provide the necessary moisture content until the mixture is uniform throughout.
>
> (c) Road Mix Method. After material for each layer has been placed, the material shall be mixed at required moisture content until the mixture is uniform throughout.
>
> The aggregate shall be spread on the prepared subgrade or base course and compacted in layers of the thickness shown on the

drawings. When more than one layer is required, each layer shall be shaped and compacted before the succeeding layer is placed.

Hauling equipment shall be reasonably dispersed over the surface of the previously constructed layer to minimize rutting or uneven compaction.

Three different methods are described for mixing the aggregate, water, and any additives. Under most contracts, the method is optional and the choice is up to the Contractor. However, you should always check the Supplemental Specifications for any special requirements.

By far the most common method is the "road-mix method." We'll talk about it, as well as the stationary plant and travel plant methods, later in the chapter.

At this point, turn back to the section on Job Performance Requirements in chapter 1 and read the critical incidents for JPR 3 under Aggregate Base and Surfacing. Then take the quiz on the next page.

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SEGMENT QUIZ

4-1 True or false? When more than one aggregate layer is called for, each should be spread and shaped separately--but compaction should take place only after the entire course is in place.

_____

4-2 Why should the hauling equipment ". . .be reasonably dispersed over the surface of the previously constructed layer"?

(a) To help aerate the moist aggregate.

(b) To complete the mixing process.

(c) To minimize rutting or uneven compaction.

(d) To avoid knocking down the stakes.

4-3 List the three approved methods for mixing the aggregate with other materials:

_____Method.

_____Method.

_____Method.

4-4 Under most contracts, the method of mixing is:

(a) Specified.

(b) Optional.

(c) Limited to a choice between two or three.

(d) Left up to the Inspector.

4-5 Which mixing method is most commonly used? _____

4-6 Which of the following is not among your job performance requirements on aggregate base and surfacing projects?

(a) Determine and describe procedures for dumping or spreading trucks so that the required amount of aggregate can be placed to the required dimensions.

(b) Identify from the contract where and to what dimensions aggregates are to be placed on the roadway.

(c) Direct the Contractor to use particular types of spreading/mixing equipment.

INTERPRETATION of DRAWINGS

Before aggregate placement begins, you should check the drawings to find out the:

(1) Width of spread.

(2) Thickness of layers.

(3) Number of layers.

This information is given on the typical sections sheet. Let's look at the examples in figure 4-1.

These are just two of several typical sections on an aggregate base job. What is the width of the base course? Well, the total width at the bottom of the base course--including shoulders--is 18 feet in most places and a little more than that between stations 274+53 and 282+52. Shoulders are typically 2 feet wide.

A note says that the base must be compacted in 4-inch lifts. This means that the 8-inch base will be constructed in two lifts. In chapter 3 you saw another typical section from this project, indicating that the base would be 8 inches thick in certain areas and 12 inches in others, so between two and three layers of aggregate will be constructed, depending on location.

Below the two typical sections on the preceding page you see a typical turnout plan. It shows a standard transition length of 50 feet from edge of shoulder to full turnout width. Turnout length, however, is variable--a note tells you to see the plan sheets for this information.

The two plan sheet excerpts in figure 4-2 are from plan and profile views showing a turnout. This particular turnout is on the left side of the road and is 10 feet wide. It begins at station 96+18 and ends at station 98+14.

As with all other phases of construction, you should check the Special Project Specifications for any additional requirements related to aggregate placement.

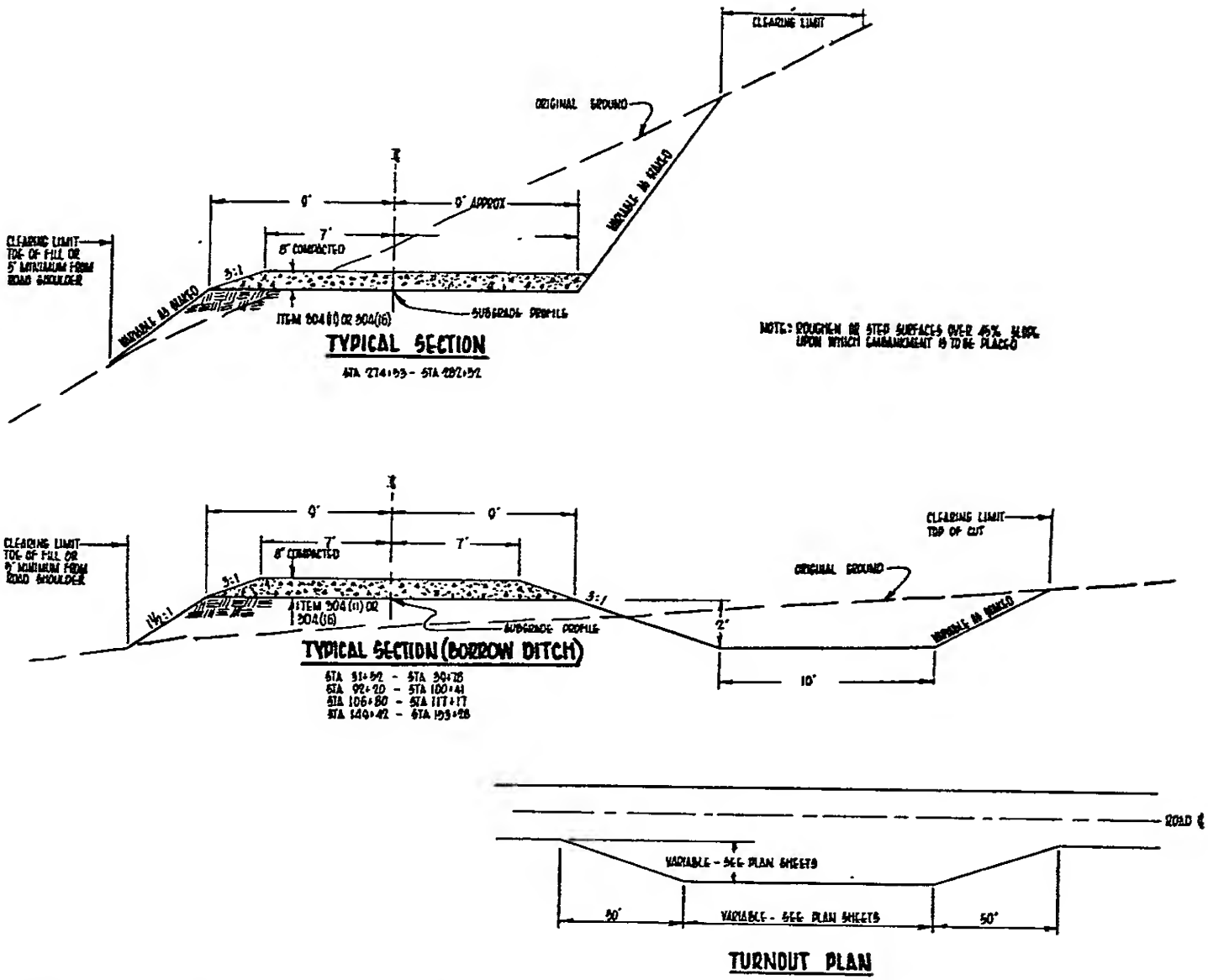


Figure 4-1.--Typical drawings for an aggregate base job.

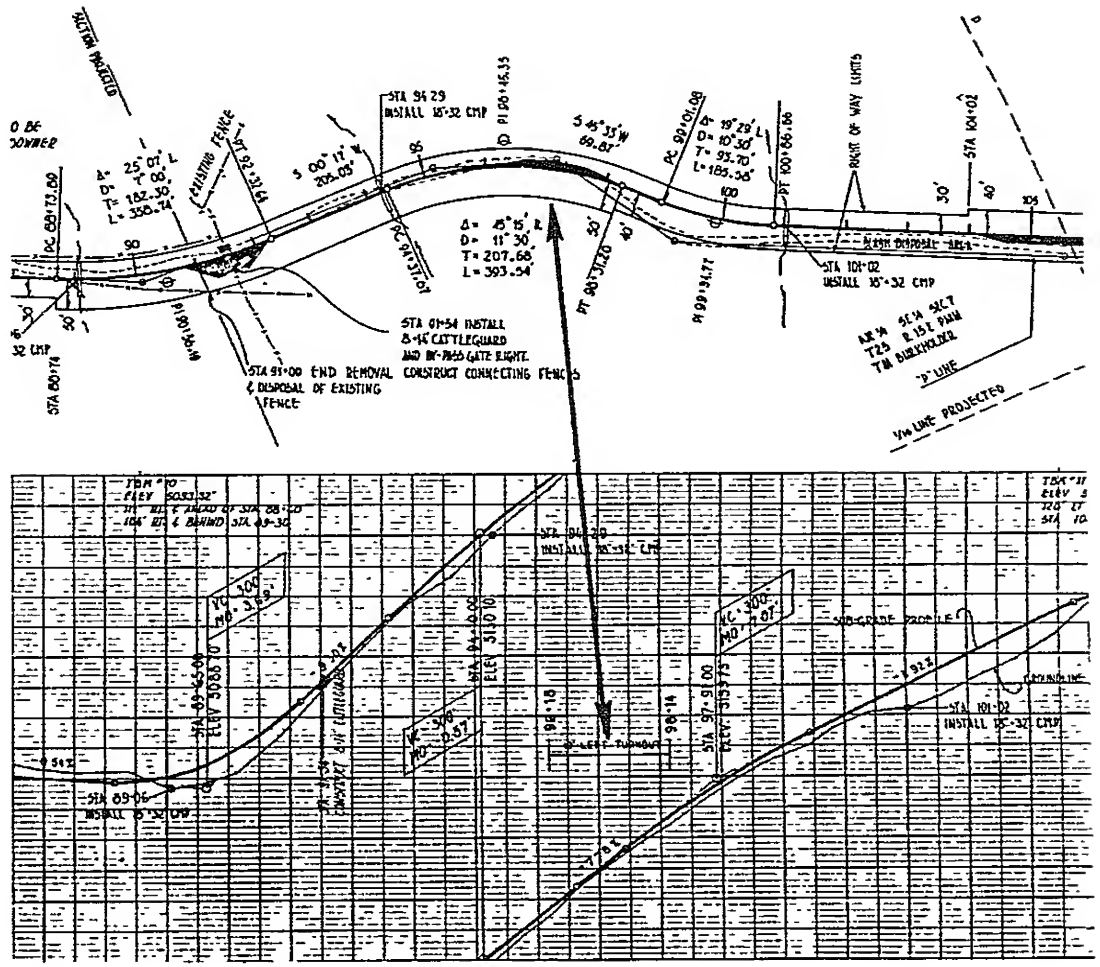


Figure 4-2.--Plan sheet excerpts.

CONTRACTOR'S PLAN of OPERATION

Just as you need to study the drawings prior to aggregate placement, you also need to learn the Contractor's plan for completing the work.

The most important thing you need to find out is the method of mixing the aggregate, as we have already discussed. Remember, there are times when the method is specified in the contract. Usually, however, the Contractor may choose the method.

Here's a list of other plan-of-operation details, in addition to the mixing method, you should learn:

(1) Sequence of work steps.

(2) Approximate schedule of operations.

(3) Haul routes.

(4) Types and numbers of equipment.

(5) Method of controlling the aggregate placement (stakes, marks, or other ground controls).

SEGMENT QUIZ

4-7 Before aggregate placement begins you should check the drawings to find out the:

(a) Number of layers to be placed.

(b) Gradation of the aggregates.

(c) Numbers and types of Contractor's equipment.

(d) Width of spread.

(e) Thickness of aggregate layers.

4-8 Refer to the typical section shown in figure 3-3. How thick should the base course be at station 253+80? _____

4-9 Which of the following should you know about the Contractor's plan of operation?

(a) Types and numbers of equipment.

(b) Method of controlling the aggregate placement.

(c) Names and experience of equipment operators.

(d) Sequence of work steps.

STOCKPILING

Stockpiles--as you know--are simply aggregate storage piles. On some projects the aggregate is produced and hauled directly to the job site. On other projects, the Contractor may elect to stockpile the aggregate after it's produced--or the Forest Service may buy stockpiled material for future use. Stockpiling provides a continuous supply of material for the road operations.

Requirements

There are several requirements for aggregate stockpiles, including:

(1) Stockpile locations must be approved by the Engineer.

(2) The site should be adequately prepared by clearing and disposing of all trees, stumps, brush, and debris. The floor for each stockpile should be reasonably uniform in cross section.

(3) Stockpiling methods and equipment must not cause or lead to segregation, degradation, or contamination of the aggregate.

(4) Stockpiles should be neat and regular in form (figure 4-3). They should occupy the smallest possible areas. The height or average depth of piles should not be less than 20 feet, except when approved by the Engineer. Side slopes should not be flatter than $1\frac{1}{2}$:1. In addition, each layer in the stockpile should have a maximum thickness of 5 feet.

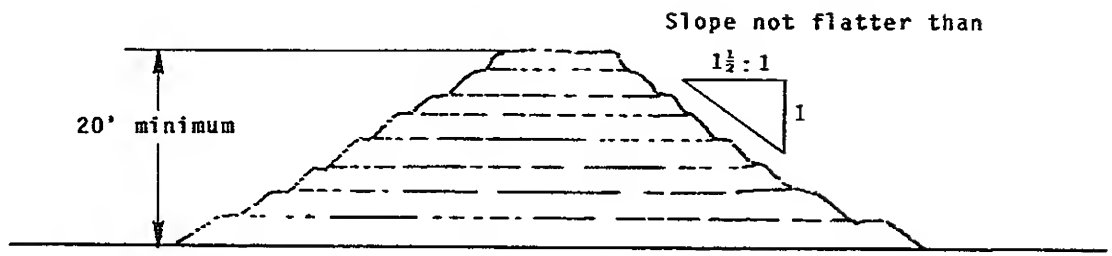


Figure 4-3.--Aggregate stockpile specification.

You should check the Supplemental Specifications for contract requirements.

Let's expand on some of the points made above by discussing the basic problems associated with stockpiling--including segregation, degradation, contamination, and excess moisture.

on

Segregation is the separation of aggregate particles into groups of different sizes, resulting in nonuniform distribution of the aggregate. Larger aggregate particles tend to end up on the bottom of the stockpile (a, figure 4-4).

One common cause of segregation is the building of stockpiles in cone shapes. To minimize segregation, stockpiles of aggregate coarser than sand should be built in layers of uniform thickness, as shown in b of figure 4-4.

Each layer should be no more than about 5 feet thick. Overlying layers should not be allowed to "cone" down over the underlying layers.

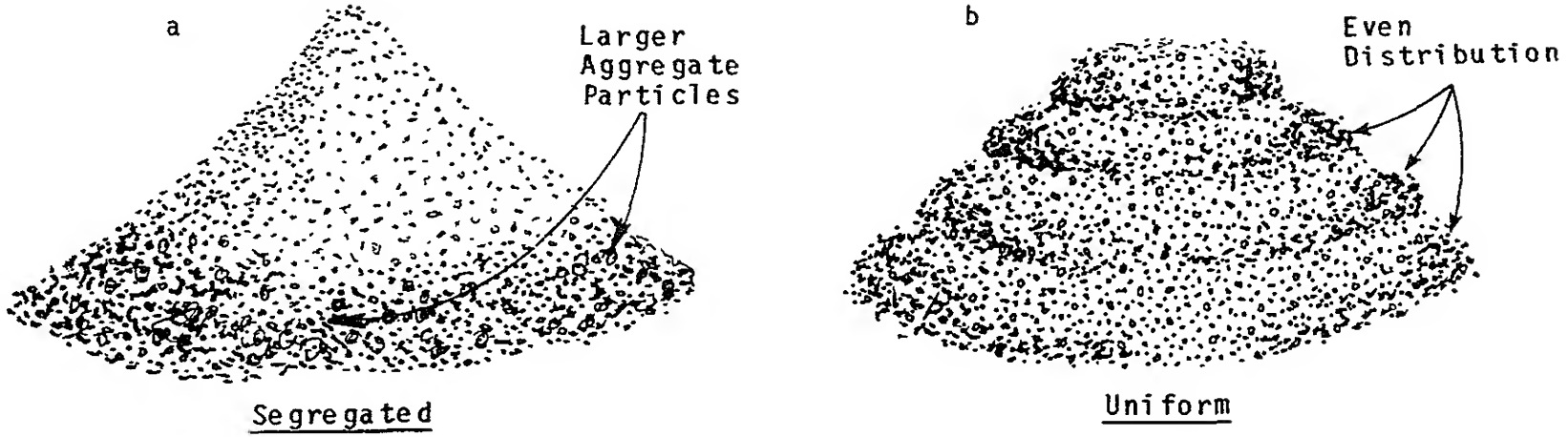


Figure 4-4.--Segregated and uniform aggregate stockpiles.

Another cause of segregation is the shifting of the stockpiles. Coarse aggregate stockpiles should not be shifted by bulldozers or similar equipment. Also, coarse aggregate must never be pushed, dumped, or cast over the sides of stockpiles.

Degradation

Degradation is the breaking down of larger aggregate particles into smaller ones. This problem may be caused by the wheels or tracks of bulldozers or similar equipment. A breaking down of particles would, of course, change gradation.

To help prevent degradation, no bulldozers or similar equipment should be allowed to operate on stockpiles. In fact, all equipment used to stockpile or remove aggregate should be observed to ensure that both degradation and segregation are avoided.

Contamination

Contamination is the pollution of aggregate by materials such as sod, vegetation, clay, or wood--or by aggregate particles of other sources, gradations, or specific gravities. Contaminants in the aggregate cause production halts while objectionable materials are removed or rejection of large amounts of aggregate--perhaps whole stockpiles.

Your goal as an Inspector should not be to discover contamination, but to be sure that good stockpiling methods are followed so that contamination is avoided.

Stockpiles should be placed on ground that has been cleared of all trees, stumps, brush, and debris. The bottom 3 inches or so of a stockpile should not be used; this ground cover of aggregate acts as a barrier to soil and foreign matter, and should not be removed until the end of the project.

Used improperly, bulldozers, front-end loaders, and other equipment can contaminate stockpiles with sod, clay, or vegetation carried on their blades, tracks, or wheels. Watch all equipment used in stockpiling closely to ensure that it is free of foreign matter.

Hopefully you will never see conditions like those in figure 4-5--although stockpiles are a common area of Contractor noncompliance. Inform the Contractor immediately whenever you find contaminated stockpiles or bad stockpiling practices. Say <u>what</u> is wrong, but not <u>how</u> to correct the problem.

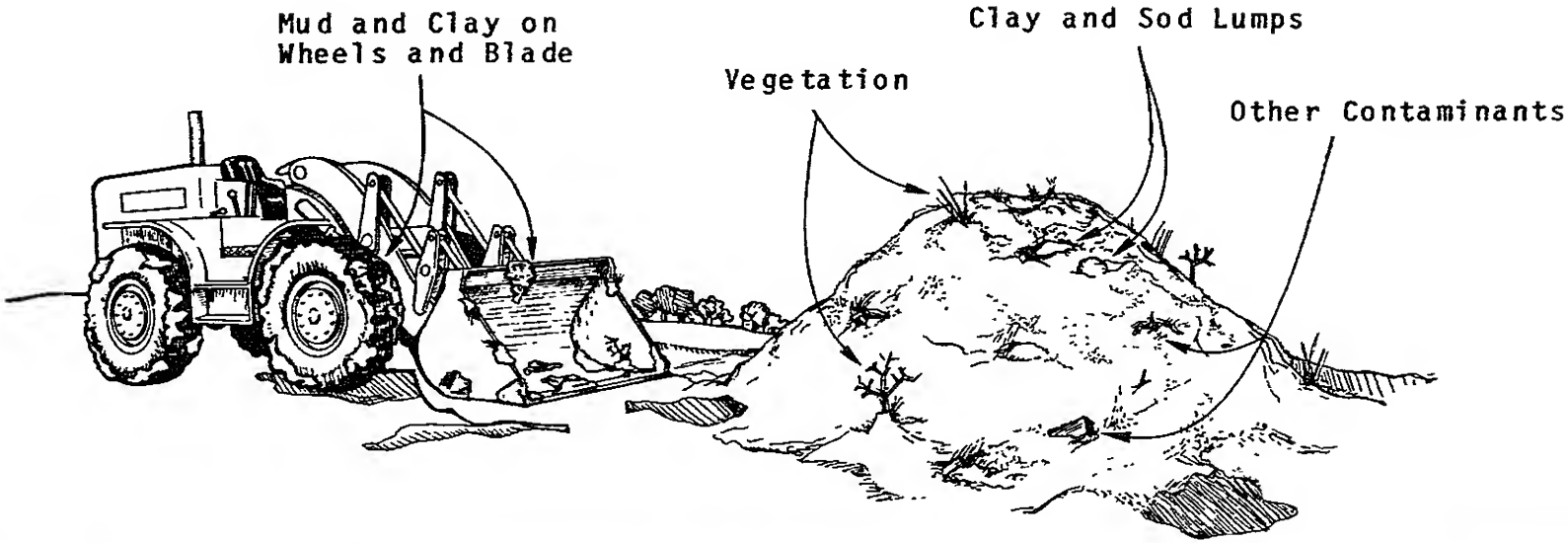


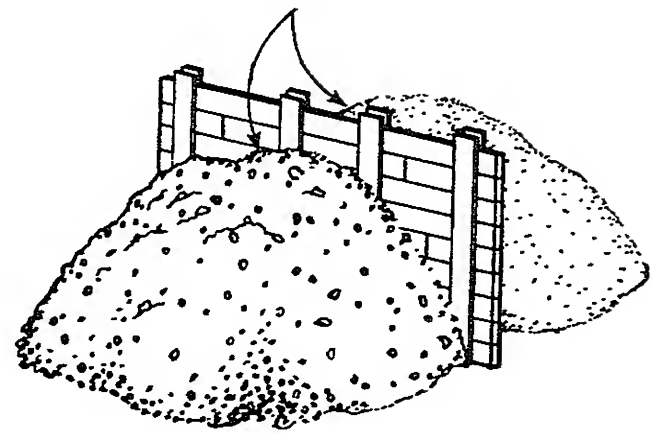
Figure 4-5.--Possible sources of aggregate contamination.

As we mentioned, aggregate of different sources or gradations should be stockpiled separately and kept from mixing. If space is limited, it may be impractical to place much distance between stockpiles. In such cases, the needed separation can be maintained with bulkheads (figure 4-6) or storage bins. Be sure that partitions are strong, free of holes, and are high and long enough to keep the stockpiles separate.

Excessive Moisture

Excessive moisture in stockpiles can interfere with the aggregate's placement, mixing, spreading, and compacting. Because of this, stockpiles should be built on ground that is firm, smooth, and well drained.

Aggregate of Different Sources or Gradations Separated By Bulkhead



Firm, Smooth, Well-Drained Ground

Figure 4-6.--Proper stockpiling practices.

SEGMENT QUIZ

4-10 Stockpile locations must be:

(a) Firm, smooth, and well drained.

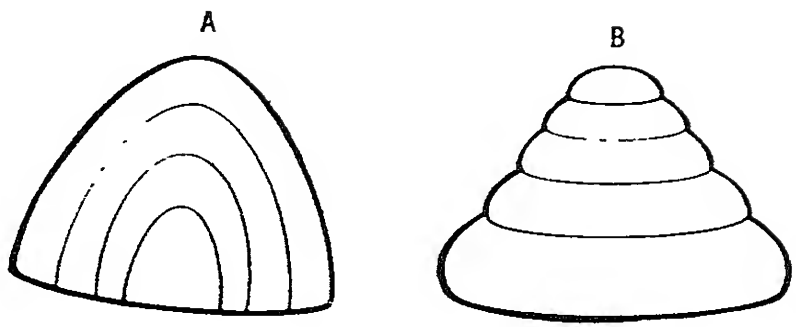
(b) Cleared of trees, stumps, brush, and debris.

(c) In low-lying areas.

(d) As large as possible.

(e) Approved by the Engineer.

4-11 Which figure shows the better method of building a stockpile? _____

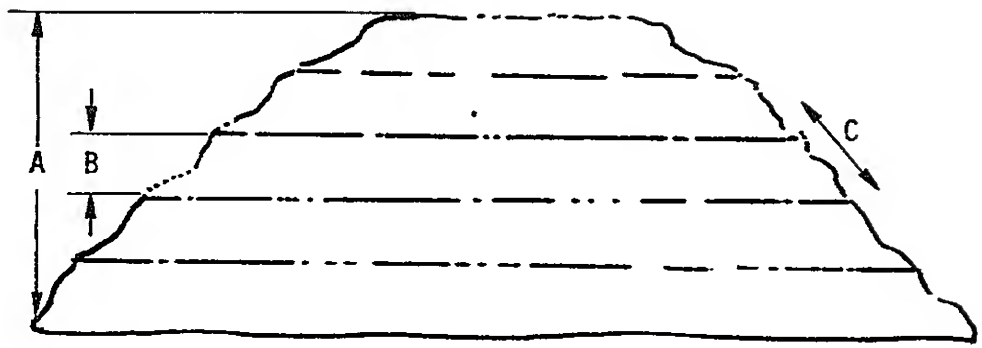


4-12 Refer to the illustration below.

(a) Minimum of _____.

(b) Maximum of _____.

(c) Not flatter than _____.



4-13 Which of the following can cause or lead to aggregate contamination?

(a) Stockpile site on high ground.

(b) Stockpile site cleared of brush and debris.

(c) Mud or clay on parts of stockpiling equipment.

(d) Missing planks in bulkhead separating stockpiles of aggregate having different gradations.

HAULING

Regardless of the method used for mixing and placing the aggregate, the aggregate will be hauled by trucks at some point. Haul trucks must be able to transport the aggregate without losing material, causing segregation, or introducing contaminants. A couple of basic points are essential:

(1) Truck beds should be constructed such that no aggregate is lost in transit--holes in truck beds or loose tailgates, for example, are definitely not permitted.

(2) Truck beds should be reasonably clean--free of debris, clay, mud, or other substances.

As the loads of aggregate arrive at the road, check the trucks for leakage and the aggregate for any signs of segregation. Also observe the effects of the hauling itself. When the trucks travel on the subgrade or on a previously placed layer of aggregate, watch out for rutting or uneven compaction.

When you notice problems, bring them to the attention of the Contractor--and the Engineer, if necessary.

CONTROLLING AGGREGATE PLACEMENT

You remember that one of the details of the Contractor's plan of operation which you must find out is the method of controlling the aggregate placement. This task is covered by critical incident "C" of JPR 3 for Aggregate Base and Surfacing:

C. Determine from the contract and Contractor's proposed plan of operation what stakes, marks, or other ground controls are needed to control the placement of aggregate to required dimensions.

When we say "required dimensions," we are talking about the length, width, and depth of spread. Regardless of the method of mixing the aggregate, the idea is to place it as close to its final location as possible. Mixing, spreading, and compacting will be greatly simplified and speeded up, and the course will be much more uniform.

The type of control needed may be determined by the mixing/spreading equipment and method. For example, when the aggregate is placed by an aggregate spreader (after being mixed in a stationary plant or before

to an exact width and depth. A stringline might be used to guide the spreader so that the correct alignment is attained.

However, as we pointed out before, the road-mix method is the most common way of mixing and spreading the aggregate. By this method the aggregate is placed on the road initially in windrows--long, narrow piles spread parallel to the centerline. The problem is how long to make the windrow so that, when mixed and spread, the aggregate covers the road to the correct width and loose depth. If the windrow is spread too short, there will be too much aggregate for that segment of base or surface course; if it's too long, there won't be enough aggregate.

So, some method of determining and marking the spread distance is needed.

The responsibility for controlling the spread distance--as well as the width and depth--is usually the Contractor's. But on some projects it is the Inspector's responsibility. Always check the contract documents to be sure.

Basically, the unit of measurement for the work determines who is responsible for controlling the spread. When the work is measured by tons or cubic yards, the Forest Service is normally responsible. A spread table, showing spread distances per ton or cubic yard of aggregate, is developed. The quantity of aggregate in each load is determined from the materials receipt (haul ticket) that comes with each truck. The spread distances for the different sizes of loads are looked up on the spread table, then staked or otherwise marked on the roadbed.

When the work is measured by lump sum, the Contractor is responsible for constructing the width and depth of the course shown on the typical sections. In this case, the Contractor is responsible for controlling the spread. The Inspector must check the final width and depth.

We'll talk about checking the width and depth of spread a little later in this chapter. For now, let's talk about using spread tables and marking spread distances.

Spread tables indicate the distances in which given numbers of tons or cubic yards of aggregate should be placed. When mixed, spread, and compacted by table standards, the aggregate will have the required width and depth. Since compaction reduces the thickness--or depth--of an aggregate layer, the placement must provide a loose depth that will compact to the desired final thickness. The spread table must, of course, allow for this.

Determining the necessary loose depth of placement requires judging the relationship between loose and compacted densities. This is largely a trial-and-error determination, requiring close observation of the early stages of placement and compaction.

Let's say we believe that to obtain a compacted layer of aggregate 4 inches thick, we'll need a loose depth of 6 inches. In other words, we believe that the aggregate will compact to about 67 percent of the loose depth.

After observing and checking the first compacted sections, however, we find that the layer is $4\frac{1}{2}$ inches thick. So we calculate that the actual compaction is to 75 percent of the loose depth.

$$4.5" \div 6" = 75\%$$

Now, to compute the necessary loose depth we divide the desired depth by the actual compaction percentage.

$$4" \div 75\% = 5.33"$$

So we want a loose spread of about $5\frac{1}{3}$ inches. When we combine this dimension with the plan's width of spread, we can compute the length of spread per cubic yard. For example, table 4-1 was calculated based on our loose depth of $5\frac{1}{3}$ inches and a width of 18 feet.

Here's how the spread distances were computed:

For 6.0 cubic yards, the Spread length =

$$\frac{6.0\ yd^3 \times 12\ in/ft \times 27\ ft^3/yd^3}{5.33\ in \times 18\ ft} = 20.26\ feet$$

Cubic Yards	Feet	Cubic Yards	Feet	Cubic Yards	Feet	Cubic Yards	Feet
6.0	20.3	6.5	22.0	7.0	23.6	7.5	25.3
6.1	20.6	6.6	22.3	7.1	24.0	7.6	25.6
6.2	20.9	6.7	22.6	7.2	24.3	7.7	26.0
6.3	21.3	6.8	23.0	7.3	24.6	7.8	26.3
6.4	21.6	6.9	23.3	7.4	25.0	7.9	26.7

Let's take an example. Suppose a haul truck arrives at the road and the driver hands you the duplicate copy of the materials receipt. The receipt says that the truck's load is 7.3 cubic yards. You look up this amount on the spread table and find a spread distance of 24.65 feet, or 24 feet 8 inches. So you stake, or otherwise mark, this distance on the roadbed. What do you measure from? You measure from the last stake which marks the end of the previous windrow. The truck driver dumps the load between the previous spread stake and the new stake, as shown in figure 4-8.

It's difficult for the drivers to control the dumping well enough to always produce uniform windrows extending exactly from the end of the previous windrow to the stake. But they usually come pretty close. Even if a windrow is dumped too long or too short, the next windrow should start at the stake. In other words, it should begin at the planned end of the previous windrow.

Table 4-1 is based on cubic yards of aggregate. But what if the unit of measurement is the ton? Well, all we need to know is the actual field-compacted dry unit weight of the aggregate. This is determined by in-place moisture-density test results, or by estimating the compaction percentage of the proctor density.

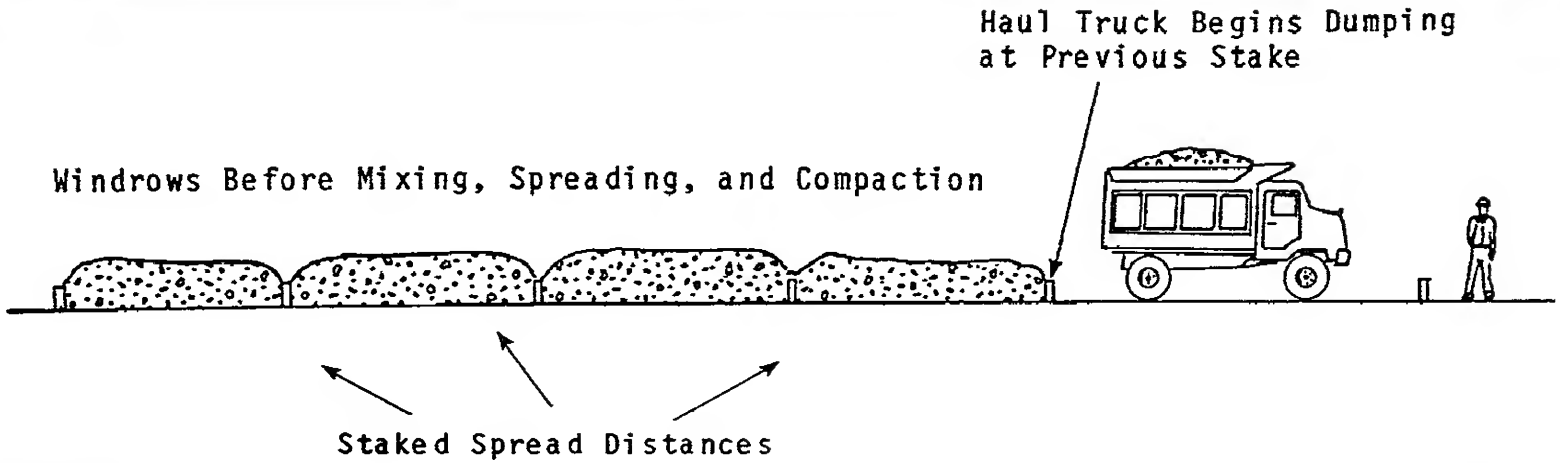


Figure 4-8.--Staking spread distances.

Typically, the dry unit weight of compacted, dense-graded crushed rock is 130 to 135 pounds per cubic foot (p.c.f.). If the aggregate is weighed wet, you'll have to increase the dry unit weight by the moisture content to obtain the wet unit weight.

Let's look at an example. Say the aggregate has a dry unit weight of 130 p.c.f. and a moisture content of 5 percent. The wet unit weight is 130 p.c.f. x 1.05 = 136.5 p.c.f. With this value and with the compacted depth and width of spread, we can compute the spread distance for any given weight of aggregate.

For example, let's say we have a truckload of 12 tons of aggregate to be compacted to a 4-inch depth and an 18-foot width.

$$\text{Spread for 12 tons} = \frac{12 \text{ tons} \times 12 \text{ in/ft} \times 2000 \text{ lb/ton}}{4 \text{ in} \times 18 \text{ ft} \times 136.5 \text{ lb/cu ft}} = 29.3 \text{ ft}$$

By such simple calculations we can develop another spread table--this one based on tons.

Table 4-2.--Aggregate base spread table
(4" compacted depth, 18' width, wet density of 136.5 p.c.f.)

Tons	Feet	Tons	Feet	Tons	Feet	Tons	Feet
12.0	29.3	13.0	31.8	14.0	34.2	15.0	36.6
12.1	29.6	13.1	32.0	14.1	34.4	15.1	36.9
12.2	29.8	13.2	32.2	14.2	34.7	15.2	37.1
12.3	30.0	13.3	32.5	14.3	34.9	15.3	37.4
12.4	30.3	13.4	32.7	14.4	35.2	15.4	37.6
12.5	30.5	13.5	33.0	14.5	35.4	15.5	37.9
12.6	30.8	13.6	33.2	14.6	35.6	15.6	38.1
12.7	31.0	13.7	33.5	14.7	35.9	15.7	38.3
12.8	31.4	13.8	33.7	14.8	36.1	15.8	38.6
12.9	31.5	13.9	33.9	14.9	36.4	15.9	38.8

SEGMENT QUIZ

4-14 Which of the following are not acceptable?

(a) Loose tailgates on haul trucks.

(b) Subgrade rutting caused by haul trucks.

(c) Even compaction of subgrade by haul trucks.

(d) Segregated loads of aggregate arriving at the road.

4-15 Most often, the aggregate is initially placed on the road in:

(a) July or August.

(b) Aggregate spreaders.

(c) Stockpiles.

(d) Windrows.

4-16 Basically, the responsibility of controlling the spread is determined by the:

(a) Unit of measurement for the work.

(b) Office of Personnel Management.

(c) Contractor.

(d) Depth of spread.

4-17 Normally, spread tables are used and spread distances are marked when the unit of work measurement is:

(a) Lump sum.

(b) Tons or lump sum.

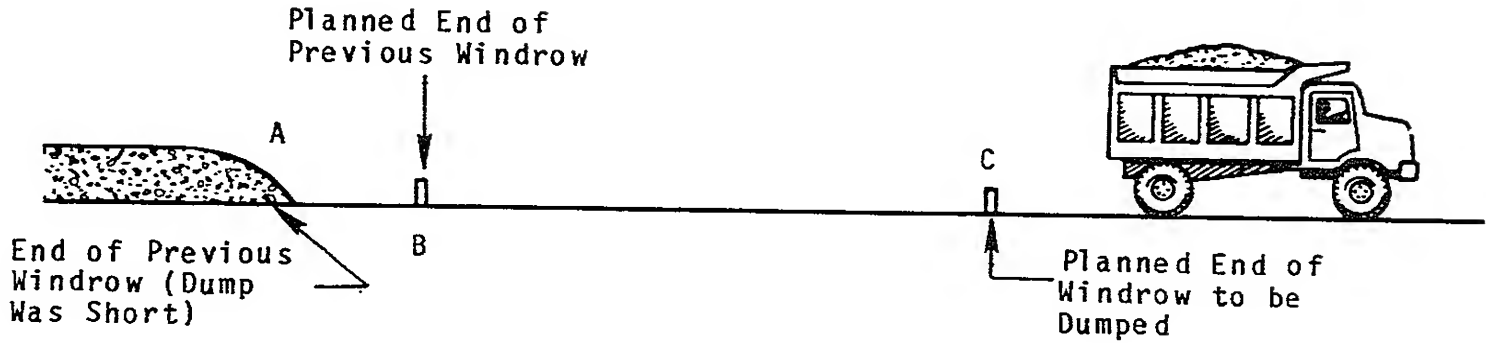
(c) Tons or cubic yards.

(d) Cubic yards or acres.

4-18 You assu[illegible].75-inch depth will be compacted to the plan's compacted thickness of 4 inches. After you check the first compacted sections, however, you find that the compacted thickness is 4.5 inches. What should the loose depth be adjusted to? _____

4-19 If aggregate is to be placed 20 feet wide and at a loose depth of 5.5 inches, what should be the spread distance for a 7.5-cubic-yard load? _____

4-20 Refer to the figure below. Where should the next haul truck start dumping? _____



4-21 Suppose the aggregate has a compacted dry unit weight of 132 p.c.f. Its moisture content is 4.3 percent. The aggregate is to be spread over a 24-foot wide area at a compacted depth of 5 inches. Compute the spread distance for a 13.8-ton load of material. _____

PLACING, MIXING, & SPREADING the AGGREGATE

Let's get into the inspection of the actual placing, mixing, and spreading operations. We'll talk about the road-mix method mainly, and briefly describe the travel plant and stationary plant methods. But first, let's go over the standard requirements.

(1) The aggregate must be placed without causing segregation or contamination of the material.

(2) The aggregate must be uniformly and thoroughly mixed with water and any needed filler, binder, or chemical additives.

(3) The mixed aggregate must be evenly spread and shaped to the required dimensions, in layers having sufficient loose depth to attain the required plan thickness when compacted.

Road-Mix Method

As the name implies, the road-mix method involves mixing the aggregate--with water and any additives--directly on the roadbed. We have said that this is by far the most commonly used of the three approved methods.

The general sequence of operations is illustrated in figure 4-9. We emphasize the word "general" because the exact sequence of steps, numbers and types of equipment, and numbers of passes are up to the Contractor.

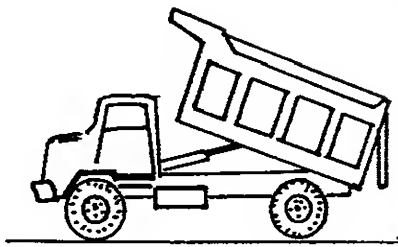
The moisture content of the aggregate is a key factor at this stage of the work. The aggregate should be mixed and spread at or near the optimum moisture content for best compaction results. You can determine the optimum content by checking the results of moisture-density relationship tests (such as AASHTO T 99), or use your own best judgment. In other words, you find out what moisture content works best by observing the behavior of previously placed and compacted aggregate.

Travel Plant Method

The travel plant method may be quite similar to the road-mix operation, with one big difference--the mixing step.

A travel plant is a self-propelled device that picks up the aggregate after it has been spread or windrowed and mixes it with water. Then, it places the mixed aggregate on the roadbed. Figure 4-10 shows the basic steps.

Placing

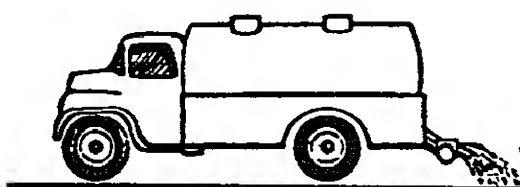


Haul trucks place aggregate in uniform windrows according to measured spread distance.

Evening Up Windrows and Initial Spreading

A motorgrader first evens up the windrows, then begins cutting out small amounts of material and spreading thin layers of aggregate

Watering



A water truck waters each layer of aggregate cut from large windrows (otherwise the water truck makes just one application, after all the aggregate is spread)

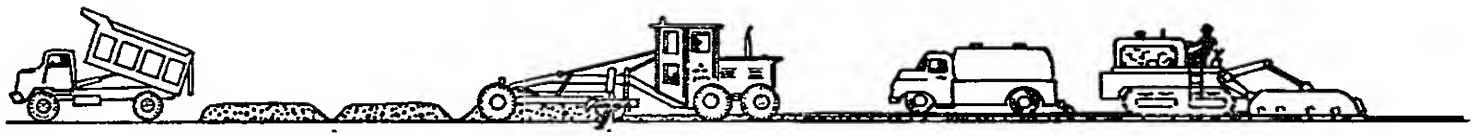
Mixing

After the aggregate has been brought to its optimum moisture content, it is mixed in place by a motorgrader.

Final Spreading ("Laydown")

Once the aggregate has been thoroughly and uniformly mixed, a motorgrader begins final spreading or "Laydown;" the course is shaped to the required dimensions.

Figure 4-9.--General sequence of the road-mix method.



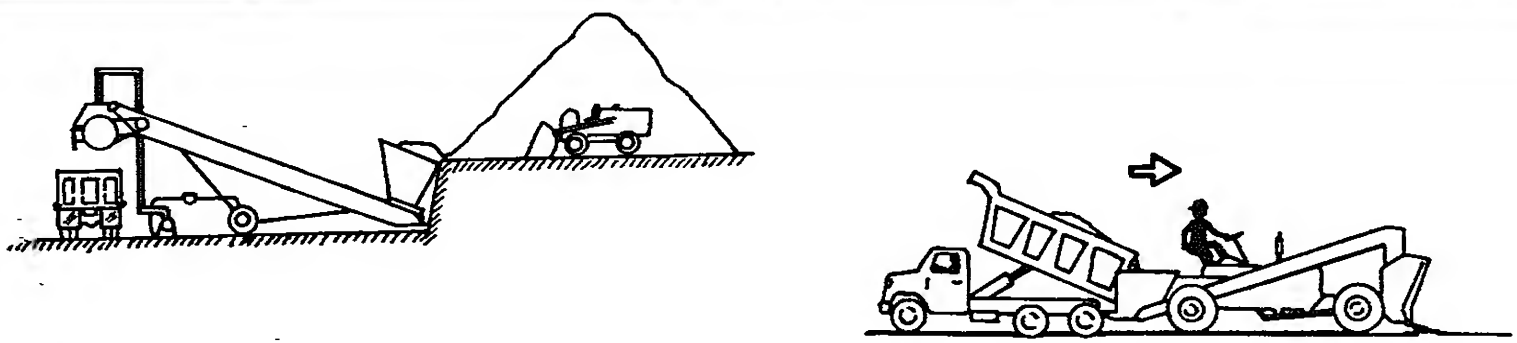
Aggregate is placed in windrows, evened up, and spread (placement may also be done by an aggregate spreader).

Water truck adds water to the spread aggregate.

Travel plant picks up aggregate and mixes it thoroughly in place.

Figure 4-10.--Travel plant mixing.

Stationary Plant Method — With the stationary plant method (figure 4-11) the aggregate is mixed in an approved mixer at a plant located away from the project. During mixing the water and any needed additives are combined with the aggregate. The mixture is hauled to the job site where it is placed, spread, and shaped by an aggregate spreader.



Stationary plant mixes aggregate, water, and any additives.

Mixed aggregate is hauled to job site and dumped into an aggregate spreader.

Aggregate spreader spreads aggregate to the required dimensions.

Figure 4-11.-Stationary plant mixing.

SEGMENT QUIZ

4-22 Number the following steps in the road mix method in the correct order.

____ (a) Motorgrader evens up windrow.

____ (b) Motorgrader mixes aggregate in place.

____ (c) Water truck waters each layer of aggregate.

____ (d) Motorgrader final-spreads the aggregate.

____ (e) Haul trucks place aggregate in windrows.

4-23 The aggregate should be mixed and spread at or near the _____ content for best compaction results.

4-24 Which of the following are true statements about travel plants?

(a) Transport aggregate to job site and spread it.

(b) Spread, shape, and compact the mixed aggregate.

(c) Mix aggregate thoroughly and place it on the road.

(d) Pick up aggregate from roadbed.

4-25 Aggregate mixed at a stationary plant is:

(a) Spread on the roadbed and shaped by an aggregate spreader.

(b) Further mixed in place on the roadbed by a motorgrader.

(c) Hauled to the job site and windrowed.

ACTION TO BE TAKEN

We've talked about the steps and typical equipment used in placing, mixing and spreading the aggregate. Your main concern, however, is not so much with how the work is done as with how well it's done.

Be sure to include the following checks in your inspection:

(1) As the aggregate is dumped from haul trucks, windrowed, mixed, and spread, inspect for segregation and contamination.

(2) Be sure that the aggregate moisture content is near optimum by the time mixing occurs.

(3) Observe the mixing for thoroughness and uniformity. Watch for overmixing--it can cause the aggregate to segregate or dry out.

(4) Watch the loose depth of spread to be sure that the correct compacted thickness can be obtained later.

(5) Check the width and thickness of the aggregate course according to the tolerances given on the drawings or elsewhere in the contract documents.

Any noncompliance in the above areas must be brought to the Contractor's attention--and to the Engineer's attention when necessary. It may be necessary for the Engineer to issue a written work order on the spot to ensure that the Contractor takes the needed corrective actions. We'll discuss Work Orders in chapter 6.

To review what you've learned in this part of the course, take the quiz beginning on the next page.

CHAPTER QUIZ

4-26 When more than one aggregate layer is called for by the contract:

(a) Water should be applied to the aggregate only for the top (final) layer.

(b) The stationary plant method should be used.

(c) Each layer should be spread, shaped, and compacted separately.

(d) Each layer should be spread and shaped separately, but all layers should be compacted at the same time.

4-27 Before aggregate placement begins, you should consult the drawings to find out the:

(a) Optimum moisture content of the aggregate.

(b) Width of spread for the aggregate.

(c) Number of aggregate layers to be placed.

(d) Number of motorgraders or other pieces of spreading equipment permitted.

(e) Thickness of aggregate layers.

4-28 The sides of aggregate stockpiles should be sloped no flatter than _____.

4-29 Is building a stockpile in 7-foot-thick layers permissible?

_____

4-30 The height of stockpiles:

(a) Should be at least 20 feet.

(b) Should be no more than 12 feet.

(c) Is indicated on the pit plan sheet of the drawings.

(d) Should be limited to 3 layers of aggregate.

4-31 Normally, monitoring of the Contractor's spread tables are the Inspector's responsibility when the unit of measurement is _____ or _____.

Aggregate Base Spread Table

Cubic Yards	Feet	Cubic Yards	Feet	Cubic Yards	Feet	Cubic Yards	Feet
6.0	20.3	6.5	22.0	7.0	23.6	7.5	25.3
6.1	20.6	6.6	22.3	7.1	24.0	7.6	25.6
6.2	21.0	6.7	22.6	7.2	24.3	7.7	26.0
6.3	21.3	6.8	23.0	7.3	24.7	7.8	26.4
6.4	21.6	6.9	23.3	7.4	25.0	7.9	26.7

4-32 A 7.7-cubic-yard load of aggregate arrives at the job site. Using the above spread table, if the last measured spread distance was to station 349+72.50, where should you place the stake to mark the end of the next spread? Station _____

4-33 Match one or more of the numbered statements with each of the lettered terms.

___ (a) Contamination.

___ (b) Degradation.

___ (c) Segregation.

(1) Nonuniform distribution of aggregate particle sizes.

(2) Aggregate from stockpiles of two different sizes of material intermixing.

(3) Caused by coning stockpiles.

(4) Bulldozer operating in stockpiles.

(5) Front-end loader with mud, clay on scoop removing aggregate from stockpile.

4-34 Before the aggregate is mixed, its moisture content should be as near _____ as possible.

4-35 At which of the following points should you check for possible segregation of the aggregate?

(a) While the aggregate is being mixed.

(b) During dumping.

(c) When the aggregate is being spread.

(d) In the windrows.

4-36 Check the _____, _____, and _____ of the aggregate course according to the tolerances given on the drawings or elsewhere in the contract documents.

4-37 To be sure that the correct compacted thickness can be obtained later, watch the:

(a) Specific gravity of the aggregate.

(b) Loose depth of spread.

(c) Performance of the compaction equipment.

(d) Overmixing of the aggregate.

CHAPTER 5
INSPECTING the COMPACTING & FINISHING

With the aggregate base or surface course properly shaped to the required dimensions, compaction may begin. Usually compacting is done close behind the final spreading and shaping of the aggregate.

Compacting forces the aggregate particles together (figure 5-1) into a denser mass without breaking them down (except in the case of grid rolling). Finer particles fill in the spaces between larger ones. Correct moisture content helps bind the particles together.

A properly compacted aggregate base or surface course is very hard, dense, and durable. Four factors directly influence compaction:

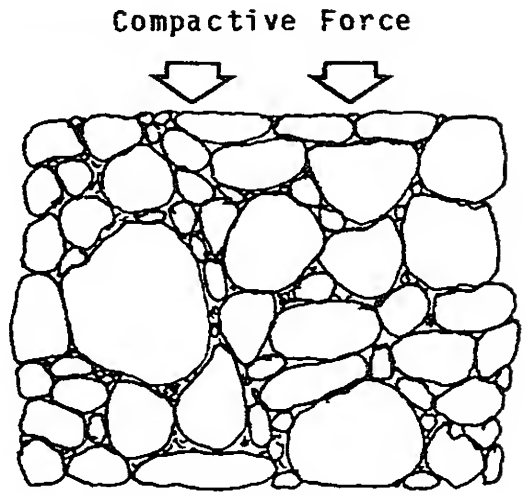


Figure 5-1.--Compaction.

(1) The gradation of the aggregate.

(2) The shape and angularity of the aggregate particles.

(3) The moisture content of the aggregate.

(4) The compaction force (weight) applied.

The purpose of compaction is to make the aggregate layers sufficiently dense to support the weight of overlying courses and/or traffic without displacement. "Density" is the key word in measuring adequate compaction.

By "finishing" we mean any final rolling or blading needed to produce a smooth, even, uniform surface. The surface condition of an aggregate base or surface course is very important.

In this chapter we will discuss inspecting the compaction and the final product--that is, the finished aggregate base or surface course. By the end of the chapter you should:

(1) Be able to determine from the contract documents and other sources the requirements, methods, and sequences for compacting and finishing aggregate base and surface courses.

(2) Know the importance of determining the Contractor's plan of operation and the equipment that will be used to compact and finish the base and surfacing.

(3) Know which tests to perform on compacted base and surface courses, as well as when to perform them and how to use test results.

(4) Be able to inspect finished aggregate base and surface courses and detect any noncompliance.

(5) Know the actions to take in case of Contractor noncompliance in compacting and finishing.

Let's begin by taking a look at the contract requirements.

CONTRACT REQUIREMENTS

The Forest Service Standard Specifications say the following:

304.10 Compaction

The aggregate shall be compacted by one of the following methods as specified on the SCHEDULE OF ITEMS:

Compaction A. Aggregate shall be compacted by operating spreading and hauling equipment over the full width of each layer of the aggregate.

Compaction B. Aggregate shall be moistened or dried to a uniform moisture content suitable for compaction. Rollers meeting the requirements of Subsection 212.02(b), (c), or (d) shall be operated over the full width of each layer until visual displacement ceases, but not fewer than three complete passes.

Compaction C. Each layer of aggregate shall be compacted to a density of at least 95 percent of the maximum density, as determined by AASHTO T 99, Method C or D.

Compaction D. Each layer of aggregate shall be compacted to a density of at least 95 percent of the maximum density, as determined by AASHTO T 180, Method C or D.

Compaction E. Each layer of aggregate shall be compacted to at least 95 percent of the target density as determined by the control strip in Subsection 212.03.

Compaction F. Pit-run and grid-rolled produced materials shall be visually moist and compacted by operating compaction equipment defined in Subsection 212.02 over the full width of each layer until visual displacement ceases.

The surface of each layer shall be bladed during the compaction operations to remove irregularities and produce a smooth, even surface. When a density requirement is specified, the density of each layer will be determined in accordance with AASHTO T 191, T 205, or T 238; T 217, T 239, or T 255; and T 224.

Notice that methods A, B, and F are Performance Type Specifications. No required minimum percentage of density is given.

Methods C and D use the standard test procedures for determining moisture-density relationships, and require the aggregate to be compacted to 95 percent of the density obtained in either AASHTO T 99 or T 180.

The last paragraph of the specification gives the requirements for finishing each layer and for testing the in-place density.

Now try the quiz on the next page.

SEGMENT QUIZ

5-1 Which of the following directly influence compaction?

(a) Width of aggregate spread.

(b) Air temperature.

(c) Moisture content of aggregate.

(d) Gradation of aggregate.

(e) Compactive force applied.

5-2 The final rolling or blading needed to produce a smooth, even, uniform surface is called _____.

5-3 Refer to the compaction requirements for crushed or screened material on page 5-3. If the maximum density of the material is 136.3 pounds per cubic foot, and a density test result shows 128.5 pounds per cubic foot, did the area represented by the test have the required minimum density? _____

5-4 For "Compaction C," may the in-place density be determined in accordance with AASHTO T 238 and T 239? _____

5-5 Who must approve the compaction equipment proposed for use?

_____

5-6 Will a vibratory steel-wheeled roller weighing 10,500 pounds be acceptable? _____

5-7 The tires of pneumatic-tired rollers must:

(a) Be of equal size.

(b) Have a smooth tread.

(c) Exert a ground pressure of at least 80 pounds per square inch.

(d) Have treads.

INSPECTING COMPACTION & FINISHING OPERATIONS

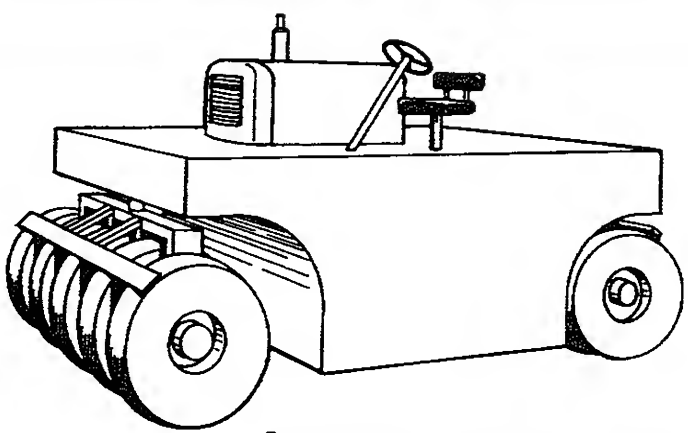
You have seen that different methods of compaction exist, and that the equipment may vary (figure 5-2). You even saw that haul trucks and spreading equipment are sometimes used to obtain adequate compaction.

Except in cases where Contractors are allowed to compact the base or surface course with hauling and spreading equipment, they normally use pneumatic- (rubber-) tired rollers or steel-wheeled vibratory rollers.

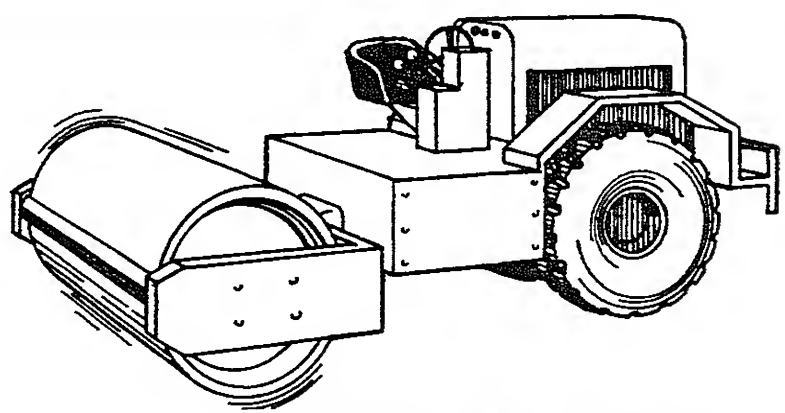
For bases or surface courses made of plastic material--such as sand-clay--sheepsfoot rollers are typically used for most of the compaction.

Normally, there are no specified rolling patterns or numbers of passes to be made. The important thing is that enough passes be made and that they cover the full width of the aggregate layer.

Some specifications, however, may call for separate payment for watering and rolling. In such cases, the Forest Service controls the number of passes. Also, the control strip technique--using a nuclear gauge under Forest Service Standard Specification 212--may be specified.



Pneumatic-Tired Roller



Steel-Wheeled Vibratory Roller

Figure 5-2.--Rollers used in compaction.

When necessary, or when required, a motorgrader should blade the surface of each layer to remove high spots, fill in low spots, and produce a smooth, even surface.

Finish rolling further compacts the course as it seals the surface; it may be required when asphalt pavement will be placed on an aggregate base course. Ordinary steel-wheeled rollers (figure 5-3) are used for finish rolling when it's called for.

Regardless of the compaction and finishing equipment and methods employed, keep these points in mind:

(1) Be sure that each layer of aggregate is compacted separately.

(2) Check the coverage of the rolling equipment. The full width of the base or surfacing--including shoulders and turnouts--must be fully and evenly compacted.

(3) Compaction equipment should not leak fuel or ballast, or in any other way damage the base or surfacing. Be sure that any other equipment requirements have been met.

(4) Inspect each finished layer's surface for smoothness and evenness. Run moisture and density tests at the required frequencies. (We'll say more about these tests next.)

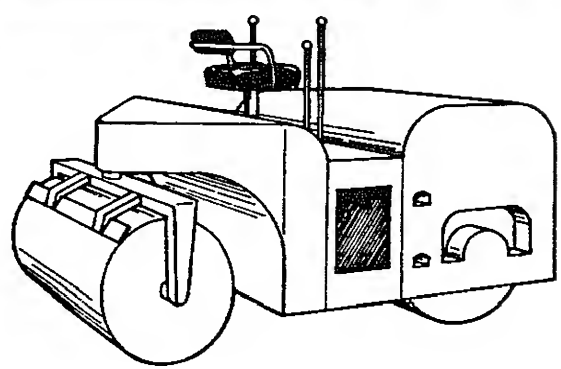


Figure 5-3.--Steel-wheeled roller.

RUNNING MOISTURE & DENSITY TESTS & INTERPRETING RESULTS

Moisture and density tests are performed to determine the in-place density and moisture content of the aggregate. As an Inspector, you should know how to run these tests. They are covered in FSH 7109.17, Chapter 24--Sampling and Testing JPR's.

You know that the results of density tests are important because they reveal how close the actual density is to the required density. Moisture tests are also important. They can indicate several things. For example, if the in-place density is satisfactory but the moisture content is not close to optimum, the contractor may get more efficient compaction by adding water. Or it may be that the optimum moisture content value is no longer correct and the moisture-density relationship test needs to be rerun. Or, too much or too little moisture may be the reason why aggregate fails to meet the required density.

Back in chapter 2 you saw part of one Region's sampling and testing schedule. The section covering moisture and density tests is reproduced in figure 5-4.

Be sure to consult your own Region's sampling and testing schedule, or the Forest Service Handbook, to learn the required frequency for running moisture and density tests. Remember, required testing frequencies are always the minimum. Run more tests than the minimum required wherever you suspect inadequate compaction.

When the result of an in-place density or moisture test fails to meet requirements, first check your calculations. If they're correct, try

Moisture-density relationship tests	Moisture-Density	AASHTO T 99	50 lb.	One test for each gradation and change in source if not too rocky for practical test.
Field tests for % compaction (density) and % moisture	% Compaction and % Moisture	Balloon AASHTO T-205 Nuclear AASHTO T-238 and T-239	As required	One for each 1/2 mile single-lane or every 1,000 tons.

Figure 5-4.--Sampling and testing schedule.

to determine if you may have made an error in running the test. You may need to run a check test in any event.

When you're sure that the percentage of compaction is incorrect, inform the Contractor immediately. Say what the test results were, but don't try to explain how to correct the problem. That's up to the Contractor. Just be sure that whatever is done to obtain proper density actually works. Run extra tests as necessary to verify that the problem has been corrected.

SEGMENT QUIZ

5-8 Which of the following is typically used for finish rolling?

(a) Rubber-tired roller.

(b) Hand tamps.

(c) Sheepsfoot roller.

(d) Steel-wheeled roller.

5-9 When may finish rolling be required for an aggregate base course?

(a) When asphalt pavement will be constructed on it.

(b) When the optimum moisture is 9 percent or greater.

(c) When the air temperature is below 40 °F.

(d) When density tests will be performed.

5-10 Should shoulders and turnouts be compacted when the traveled way is rolled? _____

5-11 Refer to figure 5-4. If you are inspecting 5.78 miles of 2-lane single-layer aggregate base course, how many moisture and density tests should you run? _____

(a) A minimum of 11.

(b) At least 24 of each.

(c) No more than 12 of each.

(d) Six density tests and six moisture tests.

5-12 You run a density test and the aggregate fails. After checking your calculations and verifying that the test has failed, what should you do next?

(a) Inform the Contractor.

(b) Nothing, if it's the first failing test.

(c) Tell the Contractor to compact a certain area of the layer with the number of passes you deem necessary.

(d) Tell the Engineer, but don't say anything to the Contractor at this point.

INSPECTING the FINISHED SURFACE

As compaction and finishing are completed, you should inspect the finished surface for two basic things: thickness and surface conditions.

The thickness must be within the tolerances set forth in Subsection 304.12 of the Forest Service Standard Specifications.

Just as you check the drawings to learn the design thickness of the aggregate layers, also check the contract documents for the thickness tolerance.

There are usually no specified frequencies for checking thickness, so you should establish your own schedule. This should be done by a statistically random method. Check often enough to satisfy yourself that the base or surface course has the correct thickness--and that that thickness is uniform. Uniform thickness provides a uniform load-carrying capacity.

Sometimes you will be able to measure thickness by probing with a rule or sharp stick. Often, however, you will need to dig holes down to the underlying layer. The latter method ensures that you measure just the layer being completed. Always be sure to fill these holes with the material you took out, and tamp them thoroughly so that no weak spots are left in the layer.

As you check the thickness, inspect the surface condition. You want to determine if the surface is sufficiently smooth, even, and free of defects.

You can perform much of this inspection by simple observation. Look for spots or areas in the surface that appear soft or too wet, and walk over them to feel whether or not the density is inadequate. Run a density test if necessary. Such places may need drying out and rerolling to correct the problem.

Watch for surface areas with obvious segregation, foreign materials, or oversized stones. If you've done a good job inspecting the earlier stages of construction, such problems should be rare.

Finally, check for surface smoothness, evenness (no high or low spots), and crown. The surface must drain--ponded water will cause

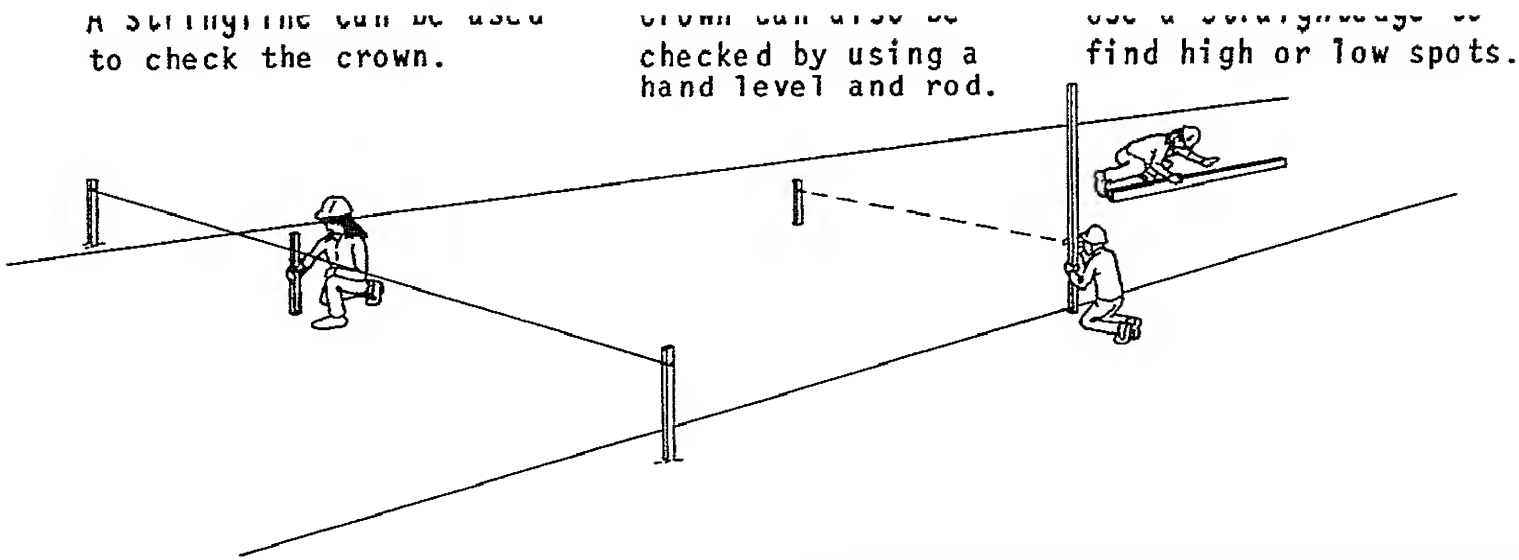


Figure 5-5.--Checking crown and evenness.

soft spots. The surface should be adequately smoothed by the final rolling, and the rough texture removed by embedding the surface aggregate particles flush with the top of the layer.

You can check the crown and find any high or low spots by using a stringline, or hand level and rod, and a straightedge as shown in figure 5-5.

Additional blading may be needed to correct defects discovered by stringlining and straightedging.

The finished aggregate base or surface course should be uniformly dense, smooth, and even.

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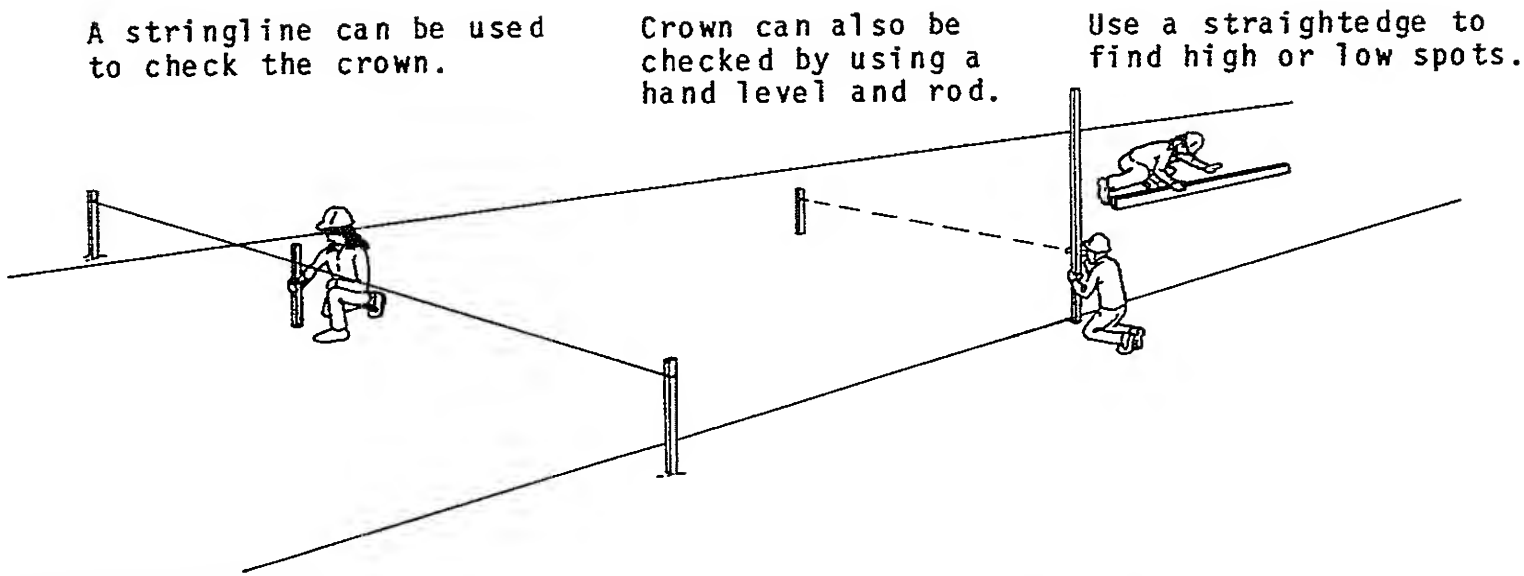

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The finished aggregate base or surface course should be uniformly dense, smooth, and even.

FINAL CLEANUP

All construction operations create certain amounts of debris, excess materials, and so forth. The Contractor is responsible for cleaning up all project sites, including the aggregate pits.

The work is covered under the following Federal Acquisition Regulation:

CLEANING UP (FAR 52.236-12) (APR 1984) (OVER $25,000; OPTIONAL UNDER)

The Contractor shall at all times keep the work area, including storage areas, free from accumulations of waste materials. Before completing the work, the Contractor shall remove from the work and premises any rubbish, tools, scaffolding, equipment, and materials that are not the property of the Government. Upon completing the work, the Contractor shall leave the work area in a clean, neat, and orderly condition satisfactory to the Contracting Officer.

As an Inspector, be sure the Contractor performs this cleanup work satisfactorily, and in accordance with the contract requirements.

CHAPTER QUIZ

5-13 Two factors which directly influence compaction are the compactive force applied and the gradation of the aggregate. Name two others.

_____

_____

5-14 An aggregate material is required to be compacted to not less than 95 percent of the maximum density of 127.8 pounds per cubic foot. If a particular test shows an in-place density of 121.6 pounds per cubic foot, does this aggregate pass or fail?

_____

5-15 What kinds of rollers are typically used to compact nonplastic aggregate layers?

_____

_____

5-16 When an aggregate base is to have asphalt pavement constructed on it, should the base be finish rolled? _____

5-17 A density test fails. Which of the following actions should you take first? Second?

(a) Write up a work order calling for additional compaction.

(b) Direct a roller operator to make a few passes over the area.

(c) Tell the Contractor that the test failed and provide the moisture and density test results.

(d) Run two more tests in the same area. If they pass, consider the first test an error.

(e) Check your calculations.

5-18 You can check the crown of the finished surface by using a _____ or _____ and _____. High and low spots can be detected using a _____.

5-19 You are checking the final compacted thickness of a base course consisting of 1-inch maximum size aggregate. The course consists of two 4-inch layers. Which of the following thickness measurements meet the requirements?

(a) $7\frac{5}{8}$ inches.

(b) $6\frac{1}{2}$ inches.

(c) $8\frac{1}{4}$ inches.

(d) 8 inches.

(e) $7\frac{3}{16}$ inches.

5-20 Which of the following should be included in the Contractor's job cleanup?

(a) Temporary construction shed.

(b) Aggregate pit 4.6 miles from road.

(c) Equipment storage area just off R/W.

(d) Shoulders and turnouts.

CHAPTER 6
MEASURING & DOCUMENTING the WORK

A vital part of inspecting any job is measuring and documenting the work. The Contractor is paid according to measurements of the work done and the materials used. These measurements--and many other details of construction--must be documented accurately and thoroughly. By the end of this chapter you should:

(1) Know the correct methods and proper procedures for measuring and documenting aggregate base and surfacing construction.

(2) Be able to measure aggregate base and surfacing work accurately.

(3) Be able to document the work neatly, accurately, and thoroughly.

CONTRACT REQUIREMENTS

Looking at Forest Service Standard Specifications Section 304, for Aggregate Base or Surface Course, we find subsections entitled "Method of Measurement" and "Basis of Payment." Let's study these two subsections.

Method of Measurement

MEASUREMENT

304.14 Method	The method of measurement as described in Section 106 will be DESIGNATED in the SCHEDULE OF ITEMS. Aggregate quantities will include mineral filler or binder.

Section 106 - Measurement & Payment

106.01 Measurement & Payment	Measurement and payment for contract work will be made only for and under those pay items included in the SCHEDULE OF ITEMS. All other work and materials will be considered as included in the payment for items shown.

When more than one class, size, or thickness is specified in the SCHEDULE OF ITEMS for any pay item, suffixes will be added to the item number to differentiate between the items.

106.02
Determination of Quantities

The following measurements and calculations are used to determine contract quantities.

For individual construction items, longitudinal and lateral measurements for area computations will be made horizontally or corrected to horizontal measurement unless otherwise specified.

For aggregates weighed for payment, the tonnage will not be adjusted for moisture content, unless otherwise provided in SPECIAL PROJECT SPECIFICATIONS.

106.03
Units of Measurement

Payment will be by units defined and determined according to U.S. Standard measure and by the following:

(a) Cubic Yard. A measurement computed by one of the following methods:

(1) Excavation, Embankment, or Borrow. The measurement computed by the average end area method from measurements made longitudinally along a centerline or reference line.

(2) Material in Place or Stockpile. The measurement computed using the dimensions of the in-place material.

(3) Material in the Delivery Vehicle. The measurement computed using measurements of material in the hauling vehicles at the point of delivery. Vehicles shall be loaded to at least their water level capacity. Leveling of

the loads may be required when vehicles arrive at the delivery point.

(b) Cubic Yard Mile. A combination of linear and volumetric measurement meaning the movement of a cubic yard of material 1 mile.

(c) Each. One complete unit, which may consist of one or more parts.

(d) MFBM. One thousand feet board measure based on nominal widths, thicknesses, and extreme usable length of each piece of lumber or timber actually incorporated in the job.

(e) Station. One hundred linear feet measured horizontally.

(f) Station Yard. A combination of linear and volumetric measurement meaning the movement of a cubic yard of material one station.

(g) Thousand Gallons Mile. A combination of linear and volumetric measurement meaning the movement of 1,000 gallons of material 1 mile.

(h) Ton. Short ton consisting of 2,000 pounds.

(i) Ton Mile. A combination of linear and weight measurement meaning the movement of 1 ton of material 1 mile.

106.04 Methods of Measurement

One of the following methods of measurement for determining final payment is DESIGNATED on the SCHEDULE OF ITEMS for each pay item:

(a) Designed Quantities (DQ). These quantities denote the final number of units to be paid for under the terms of the contract. They are based upon the original design data available prior to advertising the project.

Original design data include the preliminary survey information, design assumptions, calculations, drawings, and the presentation in the contract. Changes in the number of units SHOWN in the SCHEDULE OF ITEMS may be authorized under any of the following conditions:

(1) As a result of changes in the work authorized by the Contracting Officer.

(2) As a result of the Contracting Officer determining that errors exist in the original design that cause a pay item quantity to change by 15 percent or more.

(3) As a result of the Contractor submitting to the Contracting Officer a written request showing evidence of errors in the original design that cause a pay item quantity to change by 15 percent or more. The evidence must be verifiable and consist of calculations, drawings, or other data that show how the designed quantity is believed to be in error.

(b) Staked Quantities (SQ). These quantities are determined from staked measurements prior to construction.

(c) Actual Quantities (AQ). These quantities are determined from measurements of completed work.

(d) Vehicle Quantities (VQ). These quantities are measured or weighed in hauling vehicles.

(e) Lump Sum Quantities (LSQ). These quantities denote one complete unit of work as required by or described in the contract, including necessary materials, equipment, and labor to complete the job. They will not be measured.

Basis of Payment

As you know, all contract work is described in the FS Standard Specifications and is assigned a number. The number 304 indicates aggregate base or surface course. Because of the many combinations of pay units and items of work, separate pay items are set up. Each has its own number, as you see in the following FS Standard Specification excerpt.

PAYMENT

304.15 Basis — The accepted quantities will be paid for at the contract unit price for each pay item shown in the SCHEDULE OF ITEMS.

Pay Item		Pay Unit
304(01)	Pit Run Aggregate, Maximum Size _____, Compaction _____	C.Y.
304(02)	Pit Run Aggregate, Maximum Size _____, Compaction _____	TON
304(03)	Pit Run Aggregate, Maximum Size _____, Compaction _____	L.S.
304(04)	Grid-Rolled Aggregate, Maximum Size _____, Compaction _____	C.Y.
304(05)	Grid-Rolled Aggregate, Maximum Size _____, Compaction _____	TON
304(06)	Grid-Rolled Aggregate, Maximum Size _____, Compaction _____	L.S.
304(07)	Screened Aggregate, Grading _____, Compaction _____	C.Y.
304(08)	Screened Aggregate, Grading _____, Compaction _____	TON
304(09)	Screened Aggregate, Grading _____, Compaction _____	L.S.

304(10)	Crushed Aggregate, Type _____, Grading _____, Compaction _____ . .	C.Y.
304(11)	Crushed Aggregate, Type _____, Grading _____, Compaction _____ . .	TON
304(12)	Crushed Aggregate, Type _____, Grading _____, Compaction _____ . .	L.S.
304(13)	Furnishing and Applying Calcium Chloride, Type _____	TON
304(14)	Furnishing and Applying Hydrated Lime . . .	TON
304(15)	Furnishing and Applying Sodium Chloride . .	TON
304(16)	Placing Aggregate, Compaction _____ . .	C.Y.
304(17)	Placing Aggregate, Compaction _____ . .	TON
304(18)	Placing Aggregate, Compaction _____ . .	L.S.
304(19)	Furnishing and Applying Magnesium Chloride .	TON
304(20)	Furnishing and Applying Magnesium Chloride .	M. GALS.
304(21)	Stockpiled Aggregate, Type _____, Grading _____	C.Y.
304(22)	Stockpiled Aggregate, Type _____. Grading _____	TON

When materials are produced and furnished by the Forest Service, the note "Government furnished materials" will be added to the description of the pay item. This applies only to pay items 304(16), 304(17), and 304(18).

Modifications may be made in the basis of payment. Two examples are shown below. Both are from the Special Project Specifications.

(2) Add the following:

Pit Development will not be considered for payment but will be considered a subsidiary obligation under Item 304(11).

(2) PAYMENT

304.15
Basis

Add:

304(23) Quality Control,
Aggregate Base or Surface Course . . . L.S.

The first example includes work that would normally be measured separately under another pay item.

The second example actually adds a new pay item to the list of standard pay items shown under the Basis of Payment subsection of FS Standard Specification 304.

Schedule of Items

The pay items to be included in each project are listed in the Schedule of Items in the contract (figure 6-1).

In addition to the pay item names/numbers and the methods and units of measurement, the Schedule of Items also shows the estimated quantities of work.

So you see that the contract stipulates which work items will be done and how they will be measured.

You've seen that mineral filler or binder is not measured separately, but is included in the quantity of aggregate placed, compacted, and accepted.

You have noted also that chemical additives are measured separately. Three different pay item numbers are set up for them.

So that takes care of all our materials--except water. Water is not usually paid for separately. When it is, it will be shown in the Schedule of Items.

Take the quiz now, then we'll say more about measurement.

USDA (FOREST SERVICE) REGION 01

SUBPROJECT ESTIMATE
10/10/85

ROAD	ROAD NAME	TERMINI	MIH CODE
7007	DUCKY RIVER ROAD	0+00-52+80	LI3

IFB	DISTRICT	COUNTY	TERRAIN
457-221	DUCKY	DUCKY	SWAMPY

PAY ITEM	ITEM DESCRIPTION	MM	UNIT	QUANTITY	ENGRS ESTIMATE	TOTAL
201(01)1	CLEAR/GRUB, ST:T&L 4 L 4, 8 S 5 UOT 3	DQ	ACRE	5.10	2,150.00	10,965.00
201(09)	IND REMOVAL OF STUMPS, ST METHOD 5, 7	DQ	EA	25.00	30.00	750.00
203(02)	EXCAVATION, P.M. 2	DQ	CY	3,520.00	1.02	3,590.40
304(11)	CRUSHED AGGREGATE, GRADING D, COMP C	DQ	TON	1,735.00	5.30	9,195.50
601(01)	MOBILIZATION	LS	LS	1.00	1,800.00	1,800.00
603(01)18A	18"CMP(INCL CULV EXC)TH: STL .0640 AL .0600 MHD A	AQ	LF	210.00	18.53	3,891.30
625(05)	SEEDING, DRY METHOD (WITHOUT MULCH)	DQ	ACRE	4.70	320.00	1,504.00
					SUB PROJECT (1) TOTAL	$31,696.20
					PROJECT TOTAL	$31,696.20

Figure 6-1.--Sample schedule of items.

SEGMENT QUIZ

6-1 When the Schedule of Items includes furnishing aggregate on a lump sum basis, what kind of measurement will be necessary?

(a) Square yard.

(b) Each.

(c) Ton.

(d) None.

6-2 Chemical additives are measured by the _____.

6-3 How is pay item 304(04) to be measured? (You may refer to any of the preceding pages.) _____.

6-4 If water is to be paid for separately, where will it be indicated? _____. Where will you find the estimated quantities of work? _____.

MEASUREMENT

In the previous pages, you saw that the pay units for aggregate base or surface material include cubic yards, ton, and lump sum. While lump sum requires no measurement, the other two pay items do. Let's talk about aggregate measured by the ton first.

Ton

The ton, of course, is a unit of weight. So, if the Special Project Specifications provide for the weight to be adjusted for the moisture content of the aggregate, the main concern is the accuracy of the weighing devices. Slight variations in the percentage of moisture can make a big difference in the total measured weight of the aggregate.

Scales. Section 105 of the Forest Service Standard Specifications contains detailed requirements for the devices used for weighing the aggregate. Two types of weighing devices are covered: platform and belt conveyor scales.

Platform scales must meet the following requirements:

(1) The Contractor must provide and pay all costs associated with the scales. The aggregate must be transported in such a way that it can be weighed on the scales provided.

(2) Scale platforms that weigh haul trucks as a unit must be long enough to hold each vehicle completely and weigh all the axle loads simultaneously.

(3) The scales must be accurate within 1 percent of the correct weight throughout the range of use. The Contractor should have the scales checked before use and as often during use as necessary to ensure continued accuracy. The scales should be checked, adjusted, and certified by the State agency responsible for weights and measures or by a qualified manufacturer's representative. The Contractor is responsible for maintaining scale accuracy at all times.

(4) Tare weights of the haul trucks should be determined by weighing the empty vehicles at least once daily.

(5) All weighing is to be done by a weigher provided and paid by the Contractor.

(6) The Contractor may pay for having the material weighed on a public scale, furnishing certified weight tickets for all aggregate delivered to the project and guaranteeing permission for a Government representative to check the weighing procedure and records periodically.

Belt conveyor scales may be used in lieu of platform scales as long as the provisions of measurement and payment in the specifications are met. The requirements listed below must also be fulfilled.

(1) The belt conveyor scale must meet the design, marking, installation, and tolerance requirements of the National Bureau of Standards Handbook No. 44, and must be so certified by a copy of a National Bureau of Standards Phototype Examination Report of Test.

(2) The weighing mechanism should contain a weight totalizer and self-printing device which legibly imprints the load-out weight on appropriate serially numbered or time-dated tickets. Each ticket must be delivered to the Inspector at the job site or point of use. A security lock and key should be furnished with the totalizer calibration adjustment and ticket imprinter.

(3) Under the Engineer's or Inspector's observation, the Contractor shall run a daily zero-load test in accordance with National Bureau of Standards Handbook No. 44.

6-5 Who must provide the weigh scales? _____

6-6 Scale platforms that weigh haul trucks as a unit must:

(a) Be long enough to hold each truck completely.

(b) Be completely enclosed by a weigh-house.

(c) Have long, level approaches.

(d) Hold no more than two axles.

6-7 Scales must be accurate within _____ throughout the range of use.

(a) 25 pounds of the correct weight.

(b) 0.012 tons.

(c) One percent of the correct weight.

(d) Two percent of the correct weight.

6-8 How often should empty trucks be weighed to determine tare weights?

(a) After every load is delivered.

(b) Every week.

(c) Only when the truck is modified in some way.

(d) At least once daily.

6-9 If the weighing is <u>not</u> done on a public scale, who should provide and pay the weigher? _____

6-10 If the weighing <u>is</u> done on a public scale, what must the Contractor furnish for all aggregate delivered to the project?

_____

6-11 For belt conveyor scales, the totalizer calibration adjustment and ticket imprinter should be furnished with a:

(a) Zero-load test override.

(b) Security lock and key.

(c) Warning light or buzzer.

(d) Weigher.

Adjustment for Moisture Content (if required by Special Project Specifications). Aggregate always contains some moisture under normal conditions--moisture which may account for a significant part of the total weight of the aggregate.

For example, if the percentage of moisture in an aggregate material is 10.0 (based on dry aggregate weight) and a load of the material weighs 8.47 tons, you would compute the weights like this:

$$\textit{Dry aggregate weight} = \frac{\textit{Wet aggregate weight}}{1 + \textit{Moisture Content (as decimal)}}$$

$$= \frac{8.45 \text{ tons}}{1.1} = 7.70 \text{ tons}$$

$$\textit{Weight of water} = 0.10 \times 7.7 = 0.77 \text{ ton}$$

The 0.77 ton is nearly 1,540 pounds. Paying for 8.47 tons instead of 7.70 tons is paying for 1,540 pounds of nonexistent aggregate.

To remedy this situation, tonnage is adjusted to the dry weight of the aggregate. This usually requires that three moisture tests be run daily on the material. The results of the three tests are averaged and the average moisture percentage applied to the total aggregate placed that day. The result is an adjusted total weight of aggregate placed on the road.

So let's take an example. During a day of aggregate base construction, 871.46 tons of aggregate are placed on the road. Three moisture tests are run during the day, with results of 6.3 percent, 5.9 percent, and 6.2 percent. What is the adjusted pay quantity aggregate?

First, average the moisture test results:

$$\begin{array}{r} 6.3\% \\ 5.9 \\ +\ 6.2 \\ \hline 18.4\% \div 3 = 6.13\%. \end{array}$$

Then divide the total (wet) aggregate weight by 1.0 plus the average moisture percentage expressed as a decimal:

$$\frac{871.46 \text{ tons}}{1.0613} = 821.13 \text{ tons}$$

This 821.13 tons is the total weight of the dry aggregate placed.

Cubic Yard

Aggregate measured and paid for by the cubic yard is governed by FS Standard Specifications, subsections 106.03(2) and (3), which can be summarized as follows:

(1) The aggregate shall be measured in the haul truck at the point of delivery.

(2) All trucks should be loaded to at least their water level capacity. To check this, the Inspector may direct that certain truckloads be leveled ("struck") at the jobsite.

Okay, let's put things in order. When the pay unit for aggregate is the cubic yard, it is necessary to have the Contractor:

(1) Measure each truck that will deliver material to the road. This means you should actually take measurements of the truck bodies and make sketches as necessary to compute the volume--that is, the water level capacity or volume of water each truck would contain if filled to the maximum.

(2) Keep a record of the computed truck volumes. Write each truck number and its water level capacity beside it. You may want to keep sketches of the truck body as well, showing the critical dimensions used to compute the volume. This way you can check the Contractor's calculations at any time. You can also readily note when modifications are made to the truck bodies--alterations that increase or decrease truck capacity.

(3) Check the loaded trucks to be sure that the loads are equal to the "struck measurement." This means that, although the trucks are loaded as shown in A, figure 6-2, they would appear as shown in B when struck off (leveled).

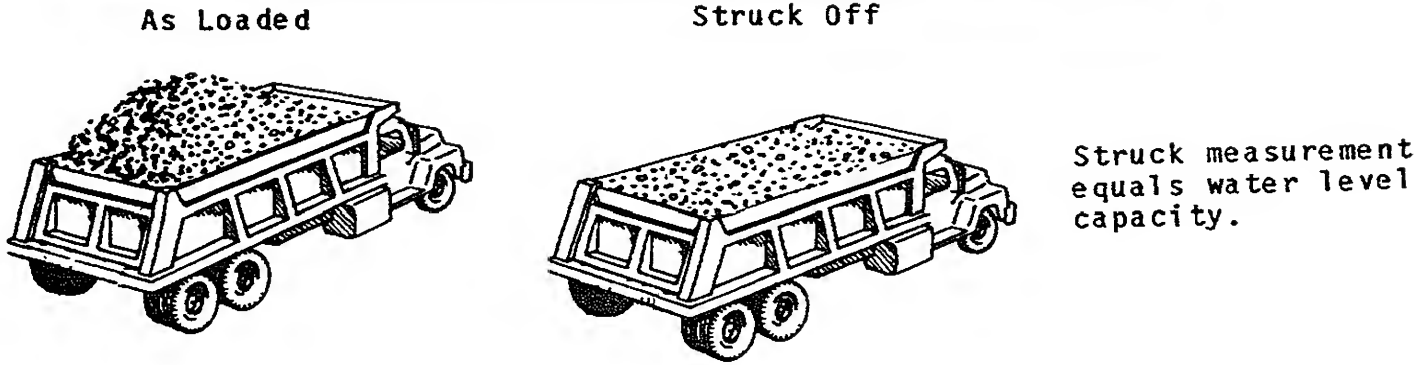

Figure 6-2.--Struck measurement.

Of course, this is a judgment on your part--estimating which loads equal the struck measurement and which don't. Remember, however, you have the authority to direct the Contractor to strike off or level any individual load to make certain it is at water level.

(4) Finally, when you determine that a truck is loaded to at least its water level capacity, have the Contractor write the previously computed volume on the haul ticket. When you find that a truck is not sufficiently loaded, have the Contractor fill it completely.

Since the validity of volume measurement depends on the accuracy of the truck volume computations, let's look at an example of these calculations.

A basic truck body shape is shown in figure 6-3. The gross volume will have to be decreased to compensate for the hoist box and the various fillets.

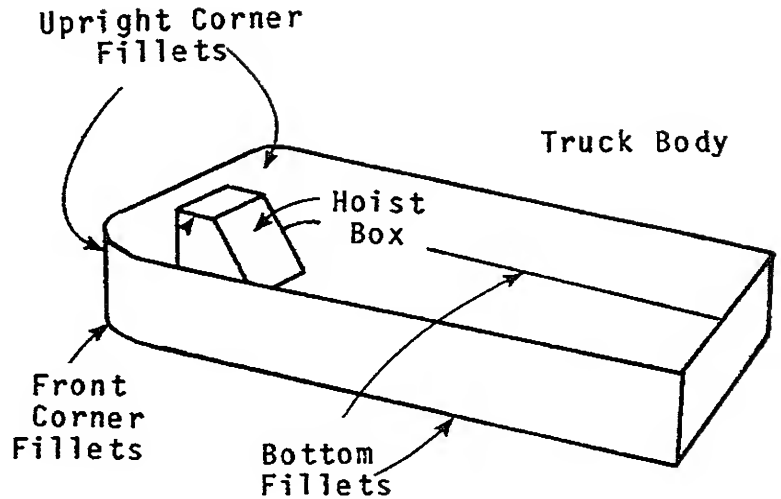

Figure 6-3.--Basic truck body shape.

Sketching the top, side, and end views of the truck body is also a good idea (figure 6-4). The measured dimensions should be shown on these views. Note the numbers of all trucks having these same dimensions.

From the dimensions, compute both the gross volume and the amounts to be deducted from it. We won't go through the math step by step, but you can see the basic formulas in figure 6-5.

TRUCK NOS. 43, 107, 228

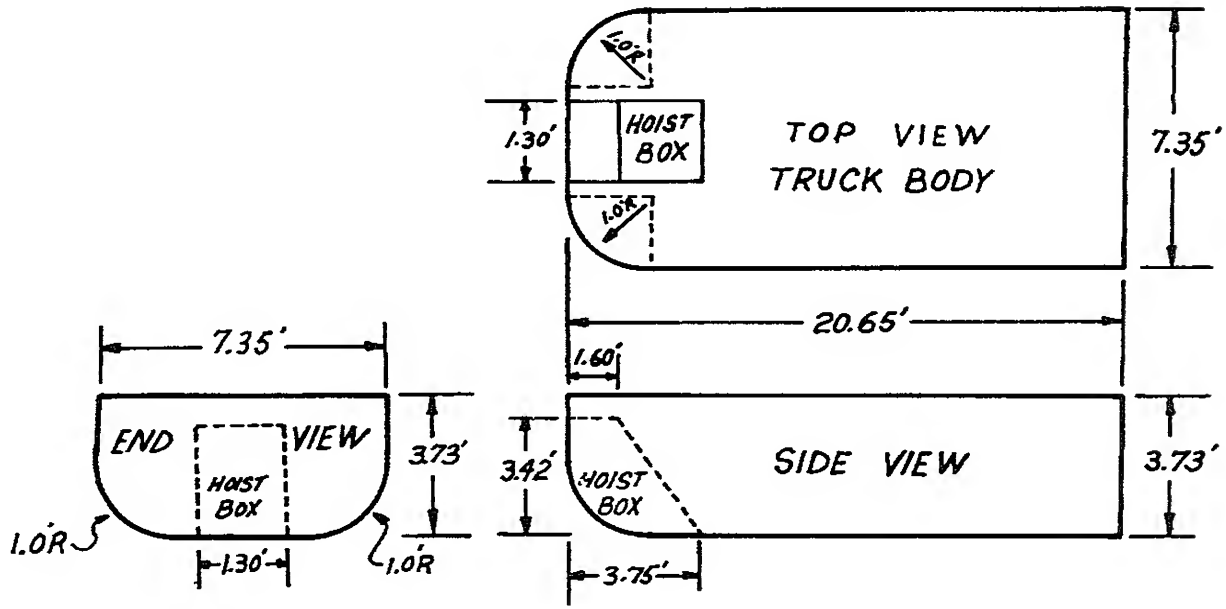

Figure 6-4.--Other views of the truck body.

GROSS VOLUME:

$L \times W \times H = V$

$20.65 \times 7.35 \times 3.73 = 566.13$ C.F.

DEDUCTIONS:

① UPRIGHT CORNER FILLETS

$\left(r^2 - \frac{\pi r^2}{4}\right) \times 2.72 \times 2$

$(1 - 0.7854) \times 5.46 =$ (1.17 C.F.)

② BOTTOM FILLETS (SIDES & FRONT)

$\left(r^2 - \frac{\pi r^2}{4}\right)(5.35 + 19.65 + 19.65)$

$(1 - 0.7854)(44.65 =$ (9.58 C.F.)

③ FRONT CORNER FILLETS

(FORMULA FOR SPHERE IS $V = \frac{4}{3}\pi r^3$)

$\left(r^2 - \frac{4\pi r^3}{3(8)}\right) 2$

$(1 - 0.5236) 2 =$ (0.95 C.F.)

④ HOIST BOX

$3.42 \times \frac{1.6 + 3.75}{2} \times 1.3 - (1 - 0.7854) 1.3$

$= 11.61$ C.F.

NET VOLUME 542.82 C.F.

USE: (542.8 CF)

This is the water level capacity or struck measurement of the truck.

Figure 6-5.--Computation of water level capacity (struck measurement).

SEGMENT QUIZ

6-12 During 1 day of aggregate base construction, 511.93 tons of aggregate are placed. The results of the aggregate moisture tests for the day are 5.1 percent, 5.2 percent, and 4.9 percent. Convert the aggregate weight to dry weight. _____

6-13 To check whether or not a truck has been loaded to its water level capacity, you can direct that the truck be:

(a) Emptied.

(b) Filled.

(c) Struck (leveled).

(d) Weighed.

6-14 Water level capacity is the same thing as:

(a) Struck measurement.

(b) Gross volume.

(c) Fillet measurement.

(d) Dry weight basis.

Other Items

Let's briefly discuss now the measurement of other items--water, filler, or binder, and chemical additives.

Water. We mentioned that water is not usually paid for separately. When it is to be paid for separately, it will appear on the Schedule of Items.

When the pay unit is lump sum, no measurement is needed.

When the pay unit "M-Gals" (M = 1,000) is shown in the Schedule of Items, the water will be measured from calibrated tanks, distributors, or accurate water meters. These will be furnished by the Contractor.

When the Schedule of Items calls for "Developing of Water Supply and Water, M-Gals," the measurement should be in M-Gals of water delivered to the project. The development of the water supply is considered incidental to the actual quantity of water furnished.

Filler or Binder. Any filler or binder added to the aggregate should be measured with the aggregate--no separate measurement needs to be made.

Chemical Additives. The measurement of aggregate, however, does not include any chemical additives. These are measured separately, by the ton. If sacked additives are used, the net weight as reported by the manufacturer will be used for measurement. The percentage of additive is usually computed on the basis of dry aggregate weight.

SEGMENT QUIZ

6-15 How many gallons are there in 43.2 M-Gals? _____

6-16 No measurement of water is necessary when the Schedule of Items shows:

(a) "M-Gals."

(b) "lump sum."

6-17 Chemical additives should be measured:

(a) By the ton.

(b) With the aggregate.

(c) By the square yard covered.

(d) Separate from the aggregate.

DOCUMENTATION

The measurement of pay quantities and many other items of information should be thoroughly, accurately, and neatly recorded in the appropriate documents. By "documents" we mean the combination of official Forest Service forms, additional regional forms, and any unofficial sketches, tally sheets, field notes, and control charts that help you to inspect, control, and report the work.

We can't discuss all the official forms and unofficial documents used in all the Regions, but let's cover the most important and typical ones, including:

(1) Materials Receipts and tally records.

(2) Contract Daily Diary.

(3) Work Orders.

(4) Gradation control charts.

We'll begin with Materials Receipts and tally records.

Materials Receipts & Tally Records

Materials Receipts are haul tickets written to document truckloads of aggregate delivered to the jobsite.

Standard Materials Receipts (FS Form 7700-24) are printed two to a sheet in booklets of 100. The cover of a booklet is shown in reduced scale in figure 6-6.

Two items must be recorded on the cover: the receipt numbers included in the booklet and the project identification.

Note the "distribution instructions."

Materials receipts should be distributed this way:

(1) The original or white copy is removed from the booklet and handed to the truck driver at the point of measurement. This white copy is for the Contractor's records.

(2) The duplicate or blue copy is also removed from the booklet and given to the driver. The driver should hand this blue copy to

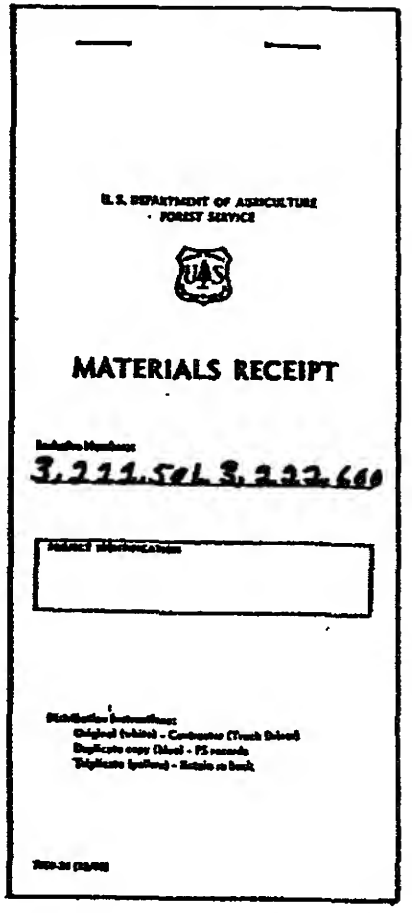

Figure 6-6.--Materials receipt booklet.

the Inspector at the road. The Inspector keeps these copies for the Forest Service records.

(3) The triplicate or yellow copy is not perforated and should not be removed from the booklet. Booklets containing just these yellow copies are saved in the project records.

If a mistake is made in writing a Materials Receipt, or if a load is rejected, the copies of the receipt should be voided. Write "VOID" in bold letters across the front of each copy and note the reason for voiding the receipt in the "Remarks" area of the receipt. Never throw away voided receipts. The copies should be distributed just as for normal receipts.

Materials receipts can be used for both weight and volume measurements of aggregate. Two examples are shown in figure 6-7.

Receipt No. 456728 was issued for aggregate measured by the ton. The weights shown are as measured by a truck scale. Receipt No. 456727 was written for aggregate measured by the cubic yard. Truck no. 53 had been previously measured and its capacity noted for easy reference.

USDA - Forest Service
7700-24 (Rev. 12/66)

No. A3222599

MATERIALS RECEIPT

Date June 19, 1978 Truck No. 721

Time 2:25 PM Load No. 108

Project Wilson Creek Rd. No. 311

Station 283+50.40 (from) 283+74.12 (to)

ITEM
Crushed Aggregate
Base 304 (1)
Grading C

Gross 24.7 Tons
Tare 10.2 "
Net 14.5 "
Other

Remarks:

Weighed by: H.A. Burgey

Received by T. Greene

USDA - Forest Service
7700-24 (Rev. 12/66)

No. A 3222600

MATERIALS RECEIPT

Date August 30, 1978 Truck No. 53

Time 9:10 AM Load No. 85

Project Otter Flat Road #140

Station 11+82.93 (from) – 12+07.59 (to)

ITEM
Crushed Aggregate
Base Course 304(10)
Grading C

Gross
Tare
Net
Other 7.3 C.Y.

Remarks:

~~Weighed by:~~ R B White

Received by N. Michaelsen

Figure 6-7.--Sample materials receipts.

Tally records are often kept as running summaries of the truckloads delivered to the project. Such tallies may be kept in field books or in other places. However, the Forest Service form "Materials Receipt Summary" (FS Form 7700-25) is tailor-made for this documentation. Study the examples shown in figure 6-8.

USDA-FOREST SERVICE

MATERIALS RECEIPT SUMMARY

CONTRACTOR: BURNSIDE CONST. Co.

CONTRACT NO.:

ITEM: CRUSHED AGGREGATE BASE 304(11) 0 GRADING

FOREST: CRAGMONT

PROJECT NO.: 311

PERIOD COVERED (Dates) From: JUNE 19, 1978 To:

RECEIPT NUMBER	TRUCK NUMBER	NET QUANTITY (TONS)
456701	153	16.7
456702	287	14.8
456703	264	13.7
456704	11	14.2
456705	102	14.4
456706	89	15.5
456707	435	13.3
456708	721	14.6

RECEIPT NUMBER	TRUCK NUMBER	NET QUANTITY ( )

USDA-FOREST SERVICE

MATERIALS RECEIPT SUMMARY

CONTRACTOR: ROAD BUILDERS INC.

CONTRACT NO.:

ITEM: CRUSHED AGGREGATE BASE 304(10) C GRADING

FOREST: DEEP RIVER

PROJECT NO.: 140

PERIOD COVERED (Dates) From: AUGUST 30, 1978 To:

RECEIPT NUMBER	TRUCK NUMBER	NET QUANTITY (Cu. YDS.)
083001	312	8.6
083002	356	7.7
083003	81	7.8
091004	224	9.4
083005	118	8.2
083006	53	7.3

RECEIPT NUMBER	TRUCK NUMBER	NET QUANTITY ( )

Figure 6-8.--Materials receipt summary.

SEGMENT QUIZ

6-18 Which of the following should be recorded on the covers of Materials Receipt booklets?

(a) Inspector's name.

(b) Project identification.

(c) Receipt numbers included in booklet.

(d) Date.

6-19 What should be done with the blue copies of the Materials Receipts?

(a) Nothing--leave them in the booklet.

(b) Driver keeps them for Contractor's records.

(c) Driver gives them to Inspector, who keeps them for Forest Service records.

(d) Staple them to the Materials Receipt Summary.

6-20 What should you do with a Materials Receipt when the load it was written for is rejected?

(a) Write "VOID" boldly across face of copies and note reason in "Remarks" area. Distribute copies properly.

(b) Remove all copies from booklet and discard them. Note on Contract Daily Diary.

(c) Neatly cross out entries and rewrite the receipt for the next load.

Tally records are often kept as running summaries of the truckloads delivered to the project. Such tallies may be kept in field books or in other places. However, the Forest Service form "Materials Receipt Summary" (FS Form 7700-25) is tailor-made for this documentation. Study the examples shown in figure 6-8.

USDA-FOREST SERVICE

MATERIALS RECEIPT SUMMARY

CONTRACTOR: BURNSIDE CONST. Co. | CONTRACT NO.:

ITEM: CRUSHED AGGREGATE BASE 304(11) GRADING O

FOREST: CRAGMONT | PROJECT NO.: 311 | PERIOD COVERED (Dates) From: JUNE 19, 1978 To:

RECEIPT NUMBER	TRUCK NUMBER	NET QUANTITY (TONS)
456701	153	157
456702	287	148
456703	264	137
456704	11	142
456705	102	144
456706	89	155
456707	435	133
456708	721	146

RECEIPT NUMBER	TRUCK NUMBER	NET QUANTITY ( )

USDA-FOREST SERVICE

MATERIALS RECEIPT SUMMARY

CONTRACTOR: ROAD BUILDERS INC. | CONTRACT NO.:

ITEM: CRUSHED AGGREGATE BASE 304(10) GRADING C

FOREST: DEEP RIVER | PROJECT NO.: 140 | PERIOD COVERED (Dates) From: AUGUST 30, 1978 To:

RECEIPT NUMBER	TRUCK NUMBER	NET QUANTITY (Cu. YDS.)
083001	312	86
083002	356	77
083003	81	78
083004	224	94
083005	118	82
083006	53	73

RECEIPT NUMBER	TRUCK NUMBER	NET QUANTITY ( )

Figure 6-8.--Materials receipt summary.

SEGMENT QUIZ

6-18 Which of the following should be recorded on the covers of Materials Receipt booklets?

(a) Inspector's name.

(b) Project identification.

(c) Receipt numbers included in booklet.

(d) Date.

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(d) Staple them to the Materials Receipt Summary.

6-20 What should you do with a Materials Receipt when the load it was written for is rejected?

(a) Write "VOID" boldly across face of copies and note reason in "Remarks" area. Distribute copies properly.

(b) Remove all copies from booklet and discard them. Note on Contract Daily Diary.

(c) Neatly cross out entries and rewrite the receipt for the next load.

Contract Daily Diary

The Contract Daily Diary (FS Form 6300-20) is the official written report of the work in progress (FSH 6309.11, Chapter 70). As the title says, it is a daily description of the project work. It should be kept every day--even on those days when the work is shut down because of bad weather, equipment breakdowns, or other reasons.

The Contract Daily Diary is the responsibility of the COR but you, as Inspector, will have a lot of input for it. You may be asked to actually write the diary too. So you should be familiar with the information needed and how and where to record it.

The diary is kept daily and submitted weekly to the Contracting Officer.

The basic diary is a one page printed form (figure 6-9). Often, however, more space is needed and the diary is continued onto another printed form, which is then attached to page one. Take the time to read carefully all the headings and recorded information in the sample diary.

Let's go over a few key items on the sample Contract Daily Diary.

Notice the identification information at the top of the first sheet: date, the time the workers arrived and left, weather conditions and temperature, ground conditions, contract number, project name, Contractor's name and address, and name of the Contractor's Representative on the job.

The numbers in the "ground conditions" box are included to help the Contracting Officer record contract progress. The top number is the time used (number of days). The second number--184 in this case--is the total contract time. And the bottom number is the percentage of contract time used.

The next sections of the form document the people and equipment used on the job. The numbers and job categories of both the Contractor's and Subcontractor's employees are listed. The types, sizes, and numbers of units of equipment are then shown, as well as which units are working and which are not.

U S DEPARTMENT OF AGRICULTURE
Forest Service

CONTRACT DAILY DIARY

(Reference FSH 6309 11)

PAGE 1 of ___

1. FOREST	2. CONTRACT NO	3 PROJECT
RATTLESNAKE	26-4012	BIG PINE ROAD

4 CONTRACTOR	5. CONTRACTOR REPRESENTATIVE ON SITE
National Construction Co.	Jim Jordan

6. GOVERNMENT OFFICIALS ON SITE
Robert Johnson, COR; Harvey Crocker, Inspector; David McHenry, Weigh Man

7. DATE	8. DAY OF WEEK	9. TIME ARRIVED	10 TIME DEPARTED	11 WEATHER
7/3/78	Mon.	7:00 a.m.	5:30 p.m.	Clear

12. TEMPERATURE °F	13 GROUND CONDITION	14 CONTRACT TIME	15 DAYS USED	16 COMPLETION DATE
Min. 45 Max 80	Dry	184	73	12/1/78

17 TIME USED (%)	18 WORK COMPLETED (%)	19 WORK ON SCHEDULE	20 CONTRACTOR'S WORK (Appropriate Box)
40	45	X YES NO	X Acceptable Unacceptable

21 CHANGE ORDERS AMENDMENTS ISSUED

22. WORK ORDERS ISSUED (Include SUSPEND RESUME

23 MATERIALS FURNISHED TO JOB SITE (Furnished By G Govt C Cont S Subcont)

2000 Tons Grading D Surfacing	C

24 EQUIPMENT ON SITE (Furnished By G Govt C Cont S Subcont)

Type	Contract Item Number and Location on site	Hours Use	
Truck 12 yd. dump, 6Ca,	Item 304 Road	60	C
Motor Patrol	Item 304 Road	10	C
Roller Pneumatic	Item 304 Road	10	C
Crusher duplex	Item 304 Pit	10	C
Truck 2000 gal water,	Item 304 Road	10	C
Tractor D-8	Item 304 Pit	10	C
Front End Loader 1½ yd.,	Item 304 Pit	10	

25 LIST CONTRACT PAYMENTS REPORTS CORRESPONDENCE ETC

Item	Prep	Submit
None		

26 WORKERS ON SITE

Classification	Number PRIME	Number SUB
Dump Truck Driver	6	
Laborer, general	2	
Motor Patrol Operator	1	
Roller Operator	2	
Water Truck Driver	1	
Crusher Operator	1	
Crusher Oiler	1	
Laborer	6	
Tractor Operator	1	
Front End Loader Operator	1	

27 GOVERNMENT PROVIDED SERVICES ADEQUATELY AND TIMELY
X YES NO Explain in narrative

28 NARRATIVE REPORT

Contractor crushed hauled and placed surfacing between sta. 435+00 and 487+50. Difficulty experienced getting proper thickness. Problem found to be adjustment of motor patrol blade which was corrected. Dry conditions required nearly constant watering.

Four samples taken off end of crusher belt.

Ran washed sieve analysis and all spec tests on one sample.

Ran dry S.A. and S.E. on other 3 samples

29. SIGNATURE	30 TITLE	31 ADDTL SPACE NEEDED
Robert H. Johnson	C.O.R.	X (continued on 6300 2A)

Distribution Original CO (weekly), copies COR SO, PROJ ENG
Previous editions of this form are obsolete

6300 20 (1/78)

Figure 6-9.--Sample Contract Daily Diary.

USDA-Forest Service

CONTRACT DAILY DIARY
Narrative Continuation
(Reference FSH 6309.11)

1. PROJECT	2. PAGE
BIG PINE ROAD	2 of 2
3 CONTRACT NUMBER	4. DATE
26-4012	7/3/78

5. NARRATIVE REPORT (continued from 6300-20)

All tests with in Specs.

Ran 2 nuclear density tests on finished surface -- OK

Tests run by Harvey Crocker

6. SIGNATURE	7. TITLE	8 ADDTL SPACE NEEDED (continued on 6300 21) On page ... of ...
Robert M. Johnson	C.O.R.	

Distribution: Original - CO (weekly); copies, COR, SO, PROJ ENG
Previous editions of this form are obsolete

6300 21 (1/78)

gure 6-9. (cont.)--Sample Contract Daily Diary.

In the next section, "Narrative Report on Status of Contract Work," note the brief description of work in progress and the explanation of problems encountered and actions taken.

Also note the information on sampling and testing, and the space provided for "materials delivered" information, Work Orders, and Suspend/Resume Orders.

Work Orders

Work Orders (FS Form 6300-12), and Suspend or Resume Work Orders (FS Form 6300-10), are issued by the Engineer as needed during the project. Printed forms are available.

Normally, the form is completed longhand since it is issued on the spot (in the field) to direct that specific items of work be done, or that work be suspended or resumed.

The forms are issued and signed by the Engineer. The Contractor, or Contractor's Representative, acknowledges receipt of the order by signing and returning copies of the form.

One example of a Work Order is shown in figure 6-10. Look it over carefully, then go on to the quiz.

U.S. Department of Agriculture
Forest Service

WORK ORDER

CONTRACT NUMBER: 38-685

PROJECT: NORTH FORK EAGLE RIVER ROAD #427

NAME AND ADDRESS OF CONTRACTOR:
ROAD MASTERS INC.
4026 NORTHRIDGE AVE
SAN FRANCISCO, CA. 94111

WORK ORDER NO.: A

DATE ISSUED: October 4, 1977

You are directed to perform the following work in connection with this contract with no adjustment in contract time or price(s):

PLACE AN ADDITIONAL 4-INCH LIFT OF BASE COURSE FROM STATION 3+00 TO 15+00 AND FROM 29+00 TO 35+00 INCLUSIVE. TAPER THIS INTO THE ORIGINAL RED TOP GRADE 200 FEET EACH WAY FROM THESE SECTIONS.

This work is included in the contract as referenced below:

REFERENCE ITEM 150

SIGNATURE: Lester Barton

TITLE: CONTRACTING OFFICER'S REPRESENTATIVE

ACKNOWLEDGEMENT–PLEASE ACKNOWLEDGE RECEIPT OF THIS NOTICE BY RETURNING _____ COPIES SIGNED IN THE SPACE BELOW:

Date October 4, 1977

Roadmaster Jones
Contractor

By Lloyd E

Title Project Superintendent

6300-12 (12/69)

6-32

Figure 6-10.--Sample Work Order.

6-21 How often should the Contract Daily Diary be kept?

(a) On all days in which work takes place.

(b) Every day.

(c) On days when significant items of work take place or new phases of construction begin.

6-22 How often is the diary submitted and to whom? _____

6-23 Which of the following items of information would typically be included in the Contract Daily Diary?

(a) Problem of obtaining adequate compaction, and solution to the problem.

(b) Percentage of contract time completed.

(c) The fact that a Subcontractor had four laborers on the project.

(d) The name of the Contractor's Representative on the job.

(e) Number of aggregate samples taken and their sources.

6-24 Which of the following items of information concerning equipment should not be included in the Contract Daily Diary?

(a) Number of units.

(b) Sizes.

(c) Whether used on the job that day or not.

(d) Types.

6-25 The issuance of Work Orders should not be documented in the Contract Daily Diary. True or false? _____

6-26 Work Orders are:

(a) Issued by the Contractor to Contractor's personnel.

(b) Issued by the Engineer on preprinted forms.

(c) Written to adjust the contract time or price(s).

(d) Typed in the office by the Inspector at the end of each week.

(e) Acknowledged by the Contractor's signing and returning of the form.

6-27 What three pay items may be used for aggregate?

_____

_____

_____

6-28 Chemical additives are measured by the:

(a) Barrel.

(b) Ton.

(c) Cubic foot.

(d) Lump sum.

6-29 Estimated quantities for the different items of work can be found in the:

(a) Schedule of Items in the contract.

(b) General Provisions.

(c) Work Orders.

(d) Typical Section Sheets of the drawings.

6-30 Platform scales that weigh individual sets of axles must:

(a) Be approved by the Contracting Officer on a Change Order.

(b) Be long enough to hold each truck completely.

(c) Have long, level approaches to accommodate the vehicles.

(d) Be provided by the Contractor.

6-31 Scales must be accurate within _____ of the correct weight throughout the range of use.

6-32 How often should truck tare weights be determined? _____

6-33 When weighing is done on a public scale, what must the Contractor furnish for all aggregate delivered to the project?

(a) Dimensions of the truck body.

(b) Certified weigh tickets.

(c) Waterproof canvas.

(d) Struck measurements.

6-34 During 1 day of aggregate base construction, 785.21 tons of aggregate are placed. The results of the aggregate moisture tests for the day are 5.8 percent, 6.3 percent, and 6.0 percent. Convert the aggregate weight to dry weight. _____

6-35 To check whether or not a truck has been loaded to at least its water level capacity, you have the authority to direct that the truck be:

(a) Measured.

(b) Filled with water.

(c) Weighed on platform scales.

(d) Struck.

6-36 How many M-Gals are in 121,350 gallons of water? _____

6-37 What should be done with the yellow copies of Materials Receipts?

(a) Leave them in the booklet.

(b) Give them to the driver.

(c) Send them to the Contractor for recordkeeping purposes.

(d) Clip them to the Contract Daily Diary.

6-38 Can Materials Receipts be used for aggregate measured by the cubic yard? _____

6-39 Which of the following statements would be true if you saw the notation below in the "ground conditions" box of a Contract Daily Diary:

$$\frac{123}{209}$$

59%

(a) There would be 209 days of contract time remaining.

(b) It would mean that 59 percent of the Contractor's personnel were skilled.

(c) 123 of 209 stations had been spread and compacted.

(d) There would be 86 days of contract time remaining.

6-40 Is the Contract Daily Diary the proper place to note how many employees the Contractor had on the job and what their job categories were? _____

CHAPTER 7
REVIEW QUIZ

This part of Aggregate Base and Surfacing Inspection is a quiz designed to help you review all that you have learned in the training course. It is also designed to help you prepare for the Aggregate Base and Surfacing Examination of the Engineering Construction Certification Program.

INSTRUCTIONS

(1) Do not take this quiz immediately after you finish chapter 6 of the course. Wait at least a day or two.

(2) Don't "cram" before you take the quiz. The objective is not to test how much you've memorized. The objective is to help you evaluate how well you can "think through" your everyday work problems.

(3) When you take this quiz, be sure that you won't be disturbed for a couple of hours.

(4) Answer all questions, either by filling in blanks or by circling the letters of correct responses.

(5) You may refer to the course material if you get stuck on a question, but first try to reason out the problem.

(6) The answers appear in chapter 8, numbered to correspond with the questions. Wait until you've completed the quiz before checking any of your answers.

QUESTIONS

7-1 In figure 7-1, the limits marked by the letter A are the:

(a) Ground line.

(b) Clearing width.

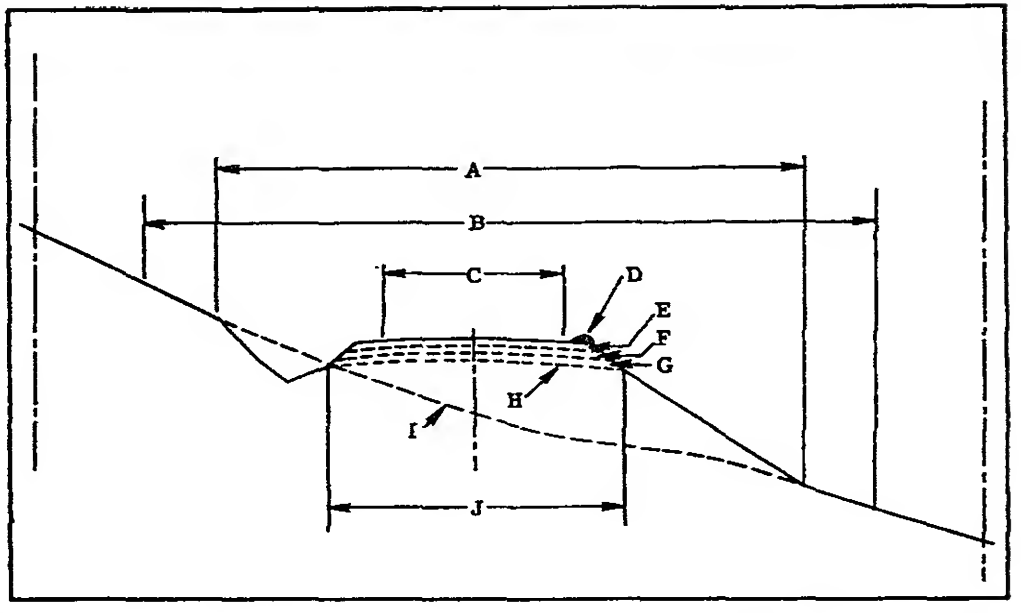


Figure 7-1.

(c) Roadway.

(d) Right-of-way.

7-2 In figure 7-1, the letter I indicates the:

(a) Groundline.

(b) Berm.

(c) Traveled way.

(d) Cut slope.

7-3 Which letter indicates the base course in figure 7-1? _____

7-4 Aggregate that can be used directly from the pit because of its well-graded condition is called:

(a) Grid-rolled aggregate.

(b) Pit-run aggregate.

(c) Plus #4 material.

(d) Filler.

7-5 Most commonly, the aggregate is dumped:

(a) In the drainage ditch alongside the road.

(b) Into neat stockpiles outside the clearing limits.

(c) Directly into travel plants.

(d) In windrows, according to predetermined spread distances.

Which document or item(s) in the following pairs has precedence over the other in cases of discrepancy?

7-6 (a) Small scale contract drawings.
(b) Large scale contract drawings.

7-7 (a) Special Project Specifications.
(b) FS Standard Specifications.

7-8 (a) FS Standard Specifications.
(b) Drawings.

7-9 "B" and "C" clauses are included in:

(a) Timber sale contracts.

(b) The General Provisions.

(c) The JPR's.

(d) Public works contracts.

7-10 As an Inspector you will work under the direct supervision of the:

(a) District Superintendent.

(b) Contractor's foreman.

(c) COR or ER.

(d) Contracting Officer.

7-11 Which of the following can be included among your inspection duties and responsibilities?

(a) Check Contractor's operations for compliance with technical specifications, drawings, work schedules, and so on.

(b) Keep progress reports.

(c) Direct Contractor's personnel on critical items of work.

(d) Issue "Stop Work" orders.

(e) Determine how work will be paid for--whether by cubic yards, tons, lump sum, or any other unit.

(f) Advise Contractor in writing about deviations from contract requirements.

(g) Specify the desired gradation for the aggregate.

(h) Identify from the contract where and to what dimensions the aggregate is to be placed on the roadway.

(i) Compare test results with contract requirements and state specifically how the aggregate meets or fails to meet contract requirements.

7-12 Aggregate sources designated by the Forest Service are either designated or described on the _____ or in the _____.

(a) Materials receipts, Contract Daily Diary.

(b) Gradation charts, test reports.

(c) Drawings, Special Project Specifications.

(d) General Provisions, JPR's.

7-13 For Government-designated sources, the equipment and work method to produce aggregate which meets the requirements are determined by the:

(a) Contractor.

(b) COR or ER.

(c) Laboratory.

(d) Inspector.

7-14 For crushing operations, the Contractor should use all suitable material with a diameter of:

(a) 12 inches or more.

(b) 12 inches or less.

(c) 6 inches or more.

(d) 4 to 10 inches.

7-15 Subtracting the plastic limit from the _____ gives the plasticity index.

(a) Durability value.

(b) Liquid limit.

(c) Proctor index.

(d) L.A. abrasion percentage.

7-16 Which of the following is <u>not</u> typically shown on pit plans?

(a) Instructions for sloping the sides of the pit.

(b) Locations of test holes.

(c) Contour (elevation) lines.

(d) Specification gradation of aggregate.

7-17 What do MESA and OSHA have to do with aggregate pits?

(a) They develop most of the crushing and screening equipment used in aggregate pits.

(b) They prescribe quarry safety requirements.

(c) They are the methods by which pit boundaries are established.

(d) They are the design units that develop pit plans.

7-18 A sieve with openings $\frac{1}{4}$-inch square is classified as a:

(a) $\frac{1}{4}$-inch sieve.

(b) No. 4 sieve.

(c) No. 16 sieve.

(d) $\frac{1}{16}$-inch sieve.

7-19 How many openings are there in 2 square inches of a No. 8 sieve? ____

7-20 Oversized aggregate is defined as material:

(a) That passes a 3-inch sieve.

(b) With a specific gravity greater than 2.65.

(c) Larger than the minimum size as shown on the Schedule of Items.

(d) Having a circumference of 12 inches or more.

7-21 Refer to the requirements for Grading D on page 2-35. Would it be acceptable for 100 percent of the aggregate to pass the $\frac{3}{4}$-inch sieve? _____

7-22 The results of a gradation test are shown below in terms of the cumulative percentages of aggregate passing each sieve. Complete the column for % Between.

Sieve Size	% Passing	% Between
$\frac{1}{2}$-inch	100	
No. 4	88	_____
No. 16	65	_____
No. 50	37	_____
No. 100	18	_____
No. 200	9	_____
Pan	0	_____

7-23 Which of the following are <u>not</u> quality tests performed on aggregate?

(a) Percentage bitumen.

(b) Sand equivalent.

(c) Plastic limit and plasticity index.

(d) Solubility.

7-24 True or false? Crushing or screening plants must be equipped with sampling devices furnished by the Contractor. _____

7-25 Aggregate acceptance test results must be obtained:

(a) Before compaction of the spread aggregate begins.

(b) Before one-third of the total length of the course has been completed.

(c) Before the aggregate is placed on the road.

(d) Before the first 15 days of contract time has elapsed.

7-26 Should you sample and test the aggregate more frequently at the beginning of production? _____

7-27 What three steps should you take when a job control test fails? (Indicate correct order with 1, 2, and 3.)

___ (a) Issue a "Stop Work" order.

___ (b) Inform Contractor and Engineer.

___ (c) Check calculations.

___ (d) Inspect pit operations, crushing, screening, and so forth.

___ (e) Have the Contractor remove all aggregate placed since last passing test.

___ (f) Run another test as a check.

7-28 Which of the following is a likely purpose for using a chemical additive in aggregate for base or surfacing?

(a) To improve the gradation.

(b) To act as a dust palliative.

(c) To increase the durability index.

(d) To reduce the need for compaction.

7-29 With crushed aggregate, any required filler should be blended:

(a) In the haul trucks.

(b) Before final rolling.

(c) During the crushing.

(d) In stockpiles.

7-30 True or false? You are designated to inspect the aggregate base and surfacing portion of a contract that includes both earthwork and aggregate base and surfacing. You should not inspect the subgrade before the aggregate base work begins because this was done as a last step in the earthwork inspection. _____

7-31 Match the sources of information on the left with the items on the right.

(a)	Profile view.	___ (1)	PC's and PT's.
		___ (2)	Base course thickness.
(b)	Typical section.	___ (3)	Elevation.
		___ (4)	Lengths of vertical curve.
(c)	Plan view.	___ (5)	Horizontal alignment.
		___ (6)	Slope rates
		___ (7)	Existing (original) groundline.

7-32 The fronts of _____ stakes face the beginning of the project.

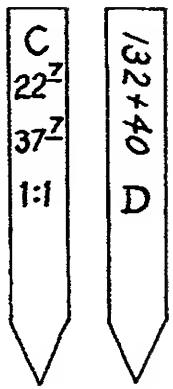
7-33 Reference, grade, slope, and control stakes face the:

(a) Centerline.

(b) End of the project.

Answer questions 7-34 and 7-35 by referring to the stake below.

Front Back



7-34 What type of stake is this? _____

7-35 The "22$\frac{7}{}$" is the:

(a) Horizontal distance to $\mathcal{L}$.

(b) Amount of cut to grade at $\mathcal{L}$.

(c) Cut height to ditch bottom.

(d) Horizontal distance from the RP.

7-36 Which of the following should be used when checking the line, grade, and cross section of roads that will be paved?

(a) Transit and rod.

(b) Stringline.

(c) Nuclear gauge.

(d) Plumb bob.

7-37 True or false? "Pumping" in a roadbed is unacceptable. _____

7-38 The drawings call for an 8-inch aggregate base to be placed in two 4-inch layers. Would it be permissible for the Contractor to place just one 8-inch lift as long as extra compaction equipment is used to obtain the required density? _____

7-39 Where would you look to find the width of spread and the number of layers for an aggregate base course?

(a) "C" clauses.

(b) Profile views of drawings.

(c) Materials receipts.

(d) Typical sections in drawings.

7-40 Stockpile locations should be:

(a) As large in area as possible.

(b) Bowl-shaped in order to collect water.

(c) Approved by the Engineer.

(d) Left in their natural state--with trees and other vegetation undisturbed.

(e) Firm, smooth, and well-drained.

7-41 Stockpiles should be built to a minimum height of _____ feet, in layers with maximum thicknesses of _____ feet, and with side slopes not flatter than _____.

(a) 20, 5, $1\frac{1}{2}$:1

(b) 10, 10, 50%

(c) 35, 3, 3:1

(d) 20, 7, 2:1

7-42 Match the terms on the left with their definitions or causes on the right.

(a)	Contamination.	___ (1)	Breaking down of larger aggregate particles into smaller ones.
(b)	Segregation.	___ (2)	Heavy equipment operating on stockpiles.
(c)	Degradation.	___ (3)	Aggregate from stockpiles of different gradations intermixing.
		___ (4)	Separation of aggregate particles into groups of different sizes.
		___ (5)	Presence of sod, vegetation, clay, or other foreign substance in stockpiles.
		___ (6)	Building cone-shaped stockpiles.

7-43 Normally, spread tables are used and spread distances marked by the Contractor when the unit of work measurement is:

(a) The station.

(b) Tons or cubic yards.

(c) Cubic yards or miles.

(d) Lump sum or tons.

7-44 Checks show that a certain aggregate material compacts to about 75 percent of its loose depth. If a compacted layer 5 inches thick is desired, what should the loose depth of spread be? _____

7-45 If the aggregate is being spread 24 feet wide and at a loose depth of 6 inches, what should be the spread distance for a 9.3-cubic-yard load? _____

7-46 Aggregate will be spread 20 feet wide with a compacted depth of 4.0 inches. Compute the spread distance for a 14.8 ton load of aggregate with a compacted dry unit weight of 130 p.c.f. and a moisture content of 5.0 percent. _____

7-47 The following actions are steps in the road-mix method. Number them in the correct order.

_____ (a) Motorgrader mixes aggregate in place.

_____ (b) Motorgrader final-spreads the aggregate.

_____ (c) Water truck waters each layer of aggregate.

_____ (d) Haul trucks place aggregate in windrows.

_____ (e) Motorgrader evens up windrows.

7-48 The aggregate should be mixed and spread at or near the _____ content for best compaction results.

7-49 Besides the road-mix method, name the other two methods of mixing/placing/spreading aggregate.

_____

_____

7-50 After the aggregate is spread, check the _____ and _____ according to the tolerances given on the drawings or elsewhere in the contract documents.

(a) Slope, station.

(b) Temperature, gradation.

(c) Width, thickness.

(d) Length, grade.

7-51 Which of the following directly influence compaction?

(a) Gradation of the aggregate.

(b) Compactive force applied.

(c) Shape and angularity of aggregate particles.

(d) Altitude.

(e) Moisture content of the aggregate.

7-52 If the compaction requirement is 95 percent of the maximum density, and the maximum density of the aggregate is 129.2 pounds per cubic foot, would a density test result of 126.8 pounds per cubic foot meet requirements? _____

7-53 True or false? The contract may specify the types and sizes of compaction equipment to be used. _____

7-54 When may finish rolling be required for an aggregate base course?

(a) When the course is thicker than 8 inches.

(b) When aggregate surface course will be placed on it.

(c) When asphalt pavement will be constructed on it.

(d) When the pay unit is lump sum.

7-55 Which of the following is typically used for finish rolling?

(a) Haul trucks.

(b) Steel-wheeled roller.

(c) Grid roller.

(d) Sheepsfoot roller.

7-56 You are running moisture and density tests on a single-layer base course according to the schedule shown below. If the 2-lane road you are inspecting is 16.59 miles long, what minimum number of each test should you run to cover the entire project? _____

Moisture-Density	AASHTO T 99	50 lb.	One test for each gradation and change in source if not too rocky for practical test.
% Compaction and % Moisture	Balloon AASHTO T-205 Nuclear AASHTO T-238 and T-239	As required	One for each 1/2 mile single-lane or every 1,000 tons.

7-57 You can check the crown of a finished aggregate surface by using a _____.

7-58 You run a density test and the aggregate fails. After verifying that it was indeed a failing sample, what should you do next?

(a) Inform the Contractor.

(b) Direct the roller operator to roll the inadequately compacted area.

(c) Have that portion of the course removed and replaced.

(d) Issue a "Stop Work" order and make a notation on the Contract Daily Diary.

7-59 Does the Contractor's responsibility for cleaning up after a job include any equipment storage areas out of the right-of-way? _____

7-60 True or false? The amount of aggregate must be measured even when the pay unit is lump sum. _____

7-61 Where will you find the complete listing of work items, with numbers, estimated quantities, and units? _____

7-62 Which of the following are usually <u>included</u> in the quantity of aggregate paid for by the ton?

(a) Water.

(b) Sodium chloride.

(c) Filler.

(d) Clearing and grubbing.

7-63 Scales must be accurate within _____ of the correct weight throughout the range of use.

7-64 How frequently should empty haul trucks be weighed to determine their tare weights? _____

7-65 During one day of aggregate base construction, 372.08 tons of aggregate are placed. The results of the aggregate moisture tests for the day are 5.6 percent, 6.2 percent, and 5.7 percent. Convert the aggregate weight to dry weight. _____

7-66 Why would you direct that a loaded haul truck be leveled?

(a) To detect any segregation.

(b) To make weighing the load easier.

(c) To conform the load to a premeasured spread distance.

(d) To determine if the truck has been loaded to its water level capacity.

7-67 If the water used in aggregate base and surfacing must be measured and paid for separately, the unit of measurement will be:

(a) Cubic yards.

(b) M-Gals.

(c) Gallons.

(d) Pounds.

7-68 Which copy of the Materials Receipts should the Inspector at the road receive from the truck driver and keep for the Forest Service records? _____

7-69 If the Materials Receipt must be cancelled for any reason, which of the following should you do?

(a) Write "VOID" on receipt.

(b) Note reason for cancellation in "Remarks" area of receipt.

(c) Remove receipt from book and destroy it.

(d) Distribute voided copies through normal channels.

7-70 True or false? The only days when the Contract Daily Diary should <u>not</u> be kept are those in which no work takes place. _____

7-71 Which of the following would <u>not</u> be documented in the Contract Daily Diary?

(a) Weather conditions.

(b) Number of aggregate samples taken and their source.

(c) Names of Contractor's personnel.

(d) Number and job categories of <u>Sub</u>contractor's personnel.

(e) Difficulties or unforeseen developments in the work.

7-72 Work Orders are:

(a) The personnel instructions of the Engineer to the Inspector.

(b) Issued to the Subcontractor by the Contractor.

(c) Issued by the Engineer to the Contractor.

(d) Issued by the Inspector to the Contractor's personnel.

SCORING YOURSELF

Although there are 72 questions in this Review Quiz, there are some 107 separate answers. Count your incorrect responses. If you missed 11 or more--that's more than 10 percent--review the areas of the course that gave you trouble. Retake quizzes as necessary to check yourself.

CHAPTER 8
ANSWERS to QUIZZES

ANSWERS for CHAPTER 1

1-1 (c)

1-2 (a) H

(b) G

(c) base course

(d) roadway

1-3 aggregate, water

1-4 (b), (c), (e)

1-5 (d), (e)

1-6 (b), (c)

1-7 pit-run

1-8 grid rolling

1-9 (b)

1-10 watered

1-11 steel-wheeled

1-12 (b)

(c)

(f)

1-13 (c)

1-14 "B," "C"

1-15 (d)

1-16 (a), (d), (f)

1-17 (a), (c), (d)

1-18 Job Performance Requirement

1-19 true

1-20 base course

1-21 (a)

1-22 timber sale

1-23 Specifications

1-24 yes

1-25 (c), (d)

ANSWERS for CHAPTER 2

2-1 (a), (b), (e)

2-2 (c)

2-3 drawings, Special Project Specifications

2-4 Government

2-5 Contractor

2-6 12 inches

2-7 (b)

2-8 no

2-9 true

2-10 Contractor

2-11 all of them

2-12 (b), (d)

2-13 $1\frac{1}{2}$:1 or flatter

2-14 relative distribution

2-15 (a)

2-16 (d)

2-17 256

2-18 (d)

2-19 (a)

2-20 Yes (0 - 6%)

2-21

% Between
3
15
20
29
21
7
5

2-22 (a), (b)

2-23 (a), (c), (e)

2-24 liquid limit

plasticity index

plastic limit

2-25 Contractor

2-26 yes

2-27 (b), (d)

2-28 65 pounds

2-29 two of each ("at least two per shift")

2-30 (a), (b), (c)

2-31 crusher, conveyor belts, stockpiles, windrows, roadbed

2-32 fail. (No. 30 sieve should have 11% to 27% passing and No. 200 should have 3% to 15%.)

2-33 (b)

2-34 (d)

2-35 MESA

2-36 (c)

2-37 (a)

2-38 yes

2-39 (d)

2-40 (c)

2-41 (c)

when conditions are unusual

2-45 2, 1, 3

2-46 yes

2-47 (a) (1)

(b) (3)

(c) (2)

2-48 (c)

2-49 gradation

2-50 (c)

2-51 (a), (b), (d)

ANSWERS for CHAPTER 3

3-1 yes

3-2 3

3-3 4, 4

3-4 all of them

3-5 (d)

3-6 (1) (b) and (c)

(2) (b)

(3) (a)

(4) (a)

(5) (c)

3-7 B

3-8 D

3-9 (d)

3-10 36.0 feet

3-11 (a)

3-12 (a)

3-13 crown, superelevation

3-14 (b), (c)

3-15 (c)

3-16 (a)

3-17 (a), (c), (d)

3-18 3 inches

3-19 (b)

3-20 (a)

3-21 (c)

3-22 (b)

3-23 (c)

3-24 (d)

3-25 (a)

ANSWERS for CHAPTER 4

4-1 false

4-2 (c)

4-3 stationary plant

travel plant

road-mix

4-4 (b)

4-5 road-mix

4-6 (c)

4-7 (a), (d), (e)

4-8 8 inches

4-9 (a), (b), (d)

4-10 (a), (b), (e)

4-11 B

4-12 (a) 20 feet

(b) 5 feet

(c) $1\frac{1}{2}$ to 1

4-13 (c), (d)

4-14 (a), (b), (d)

4-15 (d)

4-16 (a)

4-17 (c)

4-18 5.11 inches

4-19 22.09 feet (22'1")

4-20 B

4-21 20.05 feet (20'½")

4-22 (a) 2

(b) 4

(c) 3

(d) 5

(e) 1

4-23 optimum moisture

4-24 (c), (d)

4-25 (a)

4-26 (c)

4-27 (b), (c), (e)

4-28 1½ to 1

4-29 no

4-30 (a)

4-31 tons, cubic yards

4-32 349+98.5

4-33 (a) (2), (5)

(b) (4)

(c) (1), (3)

4-34 optimum

4-35 all of them

4-36 width, line, depth

4-37 (b)

ANSWERS for CHAPTER 5

5-1 (c), (d), (e)

5-2 finishing

5-3 no

5-4 yes

5-5 Engineer

5-6 no--must be at least 6 tons

5-7 (a), (b), (c)

5-8 (d)

5-9 (a)

5-10 yes

5-11 (b)

5-12 (a)

5-13 moisture content of aggregate

shape and angularity of particles

5-14 pass

5-15 pneumatic- (rubber-) tired
vibratory steel-wheeled

5-16 yes

5-17 (e), (c)

5-18 stringline, hand level, rod, straightedge

5-19 (a), (c), (d)

5-20 all of them

ANSWERS for CHAPTER 6

6-1 (d)

6-2 ton

6-3 in cubic yards

6-4 Schedule of Items, Schedule of Items

6-5 Contractor

6-6 (a)

6-7 (c)

6-8 (d)

6-9 Contractor

6-10 certified weight tickets

6-11 (b)

6-12 487.23 ton

6-13 (c)

6-14 (a)

6-15 43,200 gallons

6-16 (b)

6-17 (a), (d)

6-18 (b), (c)

6-19 (c)

6-20 (a)

6-21 (b)

6-22 weekly, to the Contracting Officer

6-23 all of them

6-24 none (all should be included)

6-25 false

6-26 (b), (e)

6-27 ton

cubic yard

lump sum

6-28 (b)

6-29 (a)

6-30 (a), (c), (d)

6-31 1%

6-32 at least once daily

6-33 (b)

6-34 740.55 tons

6-35 (d)

6-36 121.35 M-Gals

6-37 (a)

6-38 yes

6-39 (d)

6-40 yes

ANSWERS for CHAPTER 7

7-1 (c)

7-2 (a)

7-3 F

7-4 (b)

7-5 (d)

7-6 (b)

7-7 (a)

7-8 (a)

7-9 (a)

7-10 (c)

7-11 (a), (b), (f), (h), (i)

7-12 (c)

7-14 (b)

7-15 (b)

7-16 (d)

7-17 (b)

7-18 (a)

7-19 128

7-20 (c)

7-21 no

7-22 % Between

12
23
28
19
9
9

7-23 (a), (d)

7-24 true

7-25 (c)

7-26 yes

7-27 (b) 3

(c) 1

(f) 2

7-28 (b)

7-29 (c)

7-30 false

7-31 (1) (c)

(2) (b)

(3) (a)

(4) (a)

(5) (c)

(6) (b)

(7) (a), (b)

7-32 centerline

7-33 (a)

7-34 slope stake

7-35 (c)

7-36 (a), (b), (d)

7-37 true

7-38 no

7-39 (d)

7-40 (c), (e)

7-41 (a)

7-42 (1) (c)

(2) (c)

(3) (a)

(4) (b)

(5) (a)

(6) (b)

7-43 (b)

7-44 6.67 (or $6\frac{2}{3}$) inches

7-45 20.93 feet (about 20'11")

7-46 32.53 feet (32'6")

7-47 (A) 4

(B) 5

(C) 3

(D) 1

(E) 2

7-48 optimum moisture

7-49 stationary plant

travel plant

7-50 (c)

7-51 (a), (b), (c), (e)

7-52 yes

7-53 true

7-54 (c)

7-55 (b)

7-56 68

7-57 stringline or level

7-58 (a)

7-59 yes

7-60 false

7-61 Schedule of Items

7-62 (a), (c)

7-63 1 percent

7-64 at least once daily

7-65 351.58

7-66 (d)

7-67 (b)

7-68 blue copy

7-69 (a), (b), (d)

7-70 false

7-71 (c)

7-72 (c)

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